U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-295 126

Water Quality Modeling for the 208 Designated Planning Areas

Houston-Galveston Area Council, TX

Prepared for

Environmental Protection Agency, Washington, DC

May 77

BIBLIOGRAPHIC DATA SHEET	1. Report No.	2.	3. Recipient's Accession No. PB295126

4. Title and Subtitle

WATER QUALITY MODELS - May 1977
Water Quality Modeling for the 208 Designated Planning Areas

5. Report Date May 1977

6.

7. Author(s) Administrative Operations Division, Water Quality Board for Houston-Galveston Area Council

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
Texas Water Quality Board
Administrative Operations Division
Texas Department of Water Resources
P.O. Box 13087, Capitol Station
Austin, TX 78711

10. Project/Task/Work Unit No.

11. Contract/Grant No.

12. Sponsoring Organization Name and Address
Houston-Galveston Area Council
3701 West Alabama
P.O. Box 22777
Houston, TX 77027

13. Type of Report & Period Covered
Final

14.

15. Supplementary Notes

16. Abstracts

This report covers A) the improvement of steady-state mathematical models of stream water quality for Houston "208" area, addressing each segment individually and B) stormwater models to predict BOD/DO and coliform concentrations in-stream during periods of unsteady flow in the streams of each designated segment. Inclusive within each study area are:

1) a general description of the study area along with past and present water quality conditions
2) summarization of waste dischargers
3) the choice of model and significant physical and chemical parameters
4) results of model calibration/verification attempts
5) analysis to determine sensitivity of model parameters, and
6) actual use of the model.

17. Key Words and Document Analysis. 17a. Descriptors

Water Quality Modeling for Areawide Waste Treatment Management Plan, Steady-State and Stormwater

17b. Identifiers/Open-Ended Terms

17c. COSATI Field/Group

18. Availability Statement
Unlimited distribution

19. Security Class (This Report) X UNCLASSIFIED

20. Security Class (This Page UNCLASSIFIED

21. No. of Pages 213

22. Price PCA10 / MF A01

PB 295126

WATER QUALITY MODELS

MAY 1977

HGAC HOUSTON-GALVESTON AREA COUNCIL

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

WATER QUALITY MODELING
FOR THE
208 DESIGNATED PLANNING AREAS

HOUSTON AREA STEADY-STATE MODELING REPORTS

SPRING CREEK - SEGMENT 1008

Prepared by:

Administrative Operations Division
Texas Water Quality Board
Austin, Texas

for the

Houston-Galveston Area Council

and the

U. S. Environmental Protection Agency

The preparation of this report was financed through planning grants from the U. S. Environmental Protection Agency through the Houston-Galveston Area Council.

May, 1977

TABLE OF CONTENTS

		PAGE
I.	INTRODUCTION	1
II.	DESCRIPTION OF STUDY AREA	1
III.	PRESENTATION OF DATA	2
	A) Historical Quality Problem	2
	B) Existing Water Quality	2
	C) Present Waste Loadings	4
	D) Hydrological Data	4
IV.	MATHEMATICAL MODEL FORMULATION	4
V.	MATHEMATICAL MODELING OF WATER QUALITY	6
	A) General	6
	B) Segmentation	6
	C) Hydraulics	7
	D) Atmospheric Reaeration	7
	E) Carbonaceous Demands	8
	F) Nitrogenous Demands	8
	G) Benthal Demands	9
	H) Photosynthesis/Respiration	9
	I) Coliforms	9
	J) Temperature Correction Factors	10
VI.	MODEL ANALYSIS	10
VII.	SENSITIVITY ANALYSIS	11
VIII.	RECOMMENDATIONS FOR MODEL USE	12
IX.	SUMMARY	14

LIST OF ATTACHMENTS

		PAGE
A	HOUSTON AREA - Segment Location Map	A-1
B-1	SPRING CREEK - Segment 1008	B-1
B-2	MAP LEGEND - Spring Creek	B-2
C	TWQB STREAM MONITORING DATA - Spring Creek	C-1
D-1	SPRING CREEK DIURNAL FIELD MEASUREMENTS February 3, 1976 City of Houston Survey	D-1
D-2	SPRING CREEK LABORATORY ANALYSES February 3, 1976 City of Houston Survey	D-2
D-3	SPRING CREEK DIURNAL COLIFORM ANALYSES February 3, 1976 City of Houston Survey	D-3
E-1	SPRING CREEK DIURNAL FIELD MEASUREMENTS August 4, 1976 City of Houston Survey	E-1
E-2	SPRING CREEK LABORATORY ANALYSES August 4, 1976 City of Houston Survey	E-2
E-3	SPRING CREEK DIURNAL COLIFORM ANALYSES August 4, 1976 City of Houston Survey	E-3
F	EXISTING WASTE LOADS ON SPRING CREEK	F-1
G	SPRING CREEK WASTE LOADS - August 4, 1976	G-1
H-1	SPRING CREEK SCHEMATIC	H-1
H-2	SCHEMATIC EXPLANATION	H-2
J	SPRING CREEK - QUAL-II Model Input	J-1
K	CALIBRATION - Response Curves for Spring Creek Model - August 4, 1976 Survey	K-1
L	WASTEWATER TREATMENT PLANT DISCHARGE DESCRIPTION	L-1

I. INTRODUCTION

This report has been prepared in accordance with an agreement between the Texas Water Quality Board and the Houston-Galveston Area Council covering the improvement of steady-state mathematical models of stream water quality for the Houston "208" Area. As required in TASK 2.63, the purpose of the report is to incorporate data obtained through TASK 2.62 into a steady-state stream model which can predict water quality along Spring Creek (Segment 1008). The model used is a generalized steady-state model, QUAL-II, prepared for the Environmental Protection Agency by Water Resources Engineers, Inc., in May, 1973.

A general description of the study area along with past and present water quality conditions are discussed. The major waste dischargers are summarized. The choice of model and the significant physical and chemical parameters needed as input into the model are presented. The results of the model calibration/verification attempts are presented and discussed. An analysis to determine the sensitivity of the model parameters is included. A final section discusses the actual use of the model.

II. DESCRIPTION OF STUDY AREA

The study area consists of Spring Creek (Segment 1008) from its headwaters in northeast Waller County to its confluence with the West Fork of the San Jacinto River near the upper reaches of Lake Houston in Harris County (see Attachment A). The creek is approximately 68 miles in length and has a drainage area of about 438 square miles. Tributaries include Willow Creek, Panther Branch, Mill Creek, Walnut Creek, and Brushy Creek. Cypress Creek is a major tributary to Spring Creek and is classified as a separate segment, Segment 1009. The major land use in the Spring Creek drainage area has historically been typically rural and agricultural. This condition is rapidly changing, and areas are becoming more urbanized. Significant urban growth is projected in response to the expansion of metropolitan Houston from the south. Ten municipal facilities presently discharge along Spring Creek and its tributaries (excluding Cypress Creek).

III. PRESENTATION OF DATA

A) Historical Quality Problem

The Texas Water Quality Board maintains three water quality monitoring stations on Spring Creek (see Attachment B) at Lee Road (Station No. 1008.0025), 600 feet upstream of the Cypress Creek confluence (Station No. 1008.005), and I. H. 45 (Station No. 1008.01). Dissolved oxygen and fecal coliform standards for Segment 1008 are 5.0 mg/l and 2,000/100 ml, respectively. Water quality data gathered at these stations from October 1971 to January 1977 are shown in Attachment C and indicate that the segment has had problems with low dissolved oxygen levels and high fecal coliform counts.

Since 1971, three violations of the dissolved oxygen standard have occurred at I. H. 45. The stream dissolved oxygen concentration was 4.0 mg/l in September 1972 (streamflow = 9 cfs, water temperature = 79°F), 4.0 mg/l in December 1972 (30 cfs, 73°F), and 4.6 mg/l (158 cfs, 79°F) in August 1973. Explanations for the dissolved oxygen violations include variations due to phytoplankton respiration and photosynthesis, flow variations from sewage treatment plants, plant upsets, sludge deposits, localized low stream velocities, and stormwater runoff.

The fecal coliform standard at I. H. 45 was exceeded in one out of two samples in 1972, four out of four samples in 1973, one out of six samples in 1974, and one out of three samples in 1976. At Lee Road, the standard was exceeded in one out of one sample in 1975. The fecal coliform data obtained at these stations were not collected at a frequency adequate to determine compliance with the logarithmic mean criterion.

B) Existing Water Quality

The City of Houston conducted water quality surveys on Spring Creek February 3, 1976 and August 4, 1976 in conjunction with the "208" modeling effort. These surveys were originally designed to provide data for model calibration and verification. Stream sampling stations were located on Spring Creek (see Attachment B) just below the Cypress Creek confluence, below WCID #92, and at Riley-Fussell Road, I. H. 45, FM 2978, and FM 149. Stations were also located on Cypress Creek at Tettar Road and on Panther Branch at Sawdust Road.

Field measurements were taken approximately once every three hours for twenty-four hours. The field parameters measured include dissolved oxygen, temperature, pH, and conductivity. Composite samples over the twenty-four hour period were also taken at each station for laboratory analysis. The parameters measured in the laboratory include biochemical oxygen demand, organic nitrogen, ammonia nitrogen, nitrite nitrogen, nitrate nitrogen, total phosphorus, chlorophyll a, total suspended solids, and total dissolved solids. Total coliform and fecal coliform were also determined. A summary of the diurnal field measurements and the laboratory analyses are contained in Attachment D for the February 3, 1976 survey and in Attachment E for the August 4, 1976 survey.

After the February survey, analysis of the data indicated unexpectedly low BOD values in the stream. Further investigation indicated that high chlorine residuals in the stream may have caused toxicity in the BOD test. Indications were that treatment plant operators may have increased chlorine feed rates during the surveys thus resulting in high instream chlorine residuals. For the August survey, chlorine residuals were measured and split samples were sent to the EPA lab in Houston to check laboratory procedures. Analysis of the August survey confirmed the previously suspected high chlorine residuals. As a result, the BOD values reported should be viewed carefully. The actual values may be higher than the observed BOD values.

Further analysis of the data indicates that during the February 3, 1976 survey, the average dissolved oxygen remained above the 5.0 mg/l standard at all stations. However, at I. H. 45, the measured dissolved oxygen dropped below the standard three out of the eight samples. These samples were taken 3 a.m., 6 a.m., and 9 a.m. at a stream flow of approximately 33 cfs and stream temperature at 55°F.

During the August 4, 1976 survey, the measured instream dissolved oxygen was below the standard. The average dissolved oxygen measured 3.8 mg/l at FM 149 (81°F). At FM 2978, it measured 4.6 mg/l (81°F). The dissolved oxygen dropped below 5.0 mg/l two out of eight samples at I. H. 45 (79°F). The average flow at Riley-Fussell Road during this survey was 21 cfs. As the data shows, Spring Creek is presently experiencing water quality problems based on TWQB water quality standards.

C) Present Waste Loadings

The average waste loadings during the period of January 1976 to September 1976 for dischargers along Spring Creek are presented in Attachment F. Attachment G summarizes the waste loadings during the August 4, 1976 survey that were used to calibrate the model. These waste loadings are based on the August 4, 1976 sampling survey, TWQB self-reporting data, and TWQB return flow data.

D) Hydrological Data

The United States Geological Survey maintains one continuous streamflow monitoring station on Spring Creek at Riley-Fussell Road (Station No. 8068520), one non-recording streamflow station at I. H. 45 (Station No. 8068500), and a low flow station at Lee Road (Station No. 8068600). In addition to the average daily flow obtained at the USGS station, instantaneous flows at several sampling stations were obtained during the surveys with a pygmy meter when the stream velocity was great enough or the "twig-stop watch" method when stream velocities were low. The flow at Riley-Fussell Road measured during the August 4, 1976 survey was 21 cfs. The 7 day - 2 year low flow for Spring Creek at I. H. 45 is 7.87 cfs. An unknown 18" pipe on Panther Creek was found flowing half-full during the August 4, 1976 survey. This discharge was later reported to be stormwater impoundment from the Woodlands STP.

IV. MATHEMATICAL MODEL FORMULATION

The steady-state model used for Spring Creek is QUAL-II, an expanded version of QUAL-I. The QUAL-II model was chosen because of its ability to rapidly predict water quality profiles in an advective system and because it is well-known and widely used in the field of modeling.

QUAL-II uses a set of interrelated differential mass transport equations to describe the effects of advection, dispersion, decay, sources, and sinks for all water quality constituents being modeled. The transport equations are then solved by numerical integration using an implicit-finite-difference technique under the assumption that advection along the primary axis of flow (longitudinal axis of the stream channel) is the primary mode of transport. QUAL-II is capable of simulating carbonaceous biochemical oxygen demand (BOD), nitrogenous

BOD through the nitrogen cycle, benthic oxygen demand, dissolved oxygen (DO), the nutrient cycles, algae production, coliforms, and conservative materials.

A schematic diagram of the model structure is presented in Attachment H. River reaches, which are aggregates of computation elements of equal length, are defined for stretches of the stream with uniform hydraulic and reaction characteristics. Hydraulic coefficients and exponents, reaction rate coefficients, initial conditions, and incremental runoff are assumed to be constant for all computational elements within a reach. Each computational element is considered completely-mixed and therefore has uniform water characteristics throughout with the average concentration represented as to point value in the center of each element.

Advantages

1) QUAL-II models the nitrogen cycle from organic nitrogen to ammonia to nitrite to nitrate.

2) Benthal oxygen demand and coliforms are included in the model.

3) QUAL-II is capable of modeling the algae-nutrient interactions.

4) QUAL-II is capable of handling tributaries.

5) The implicit solution technique is unconditionally stable.

6) The output is easy to read and analyze. An excellent plotting routine helps in visualizing the effects of waste loads.

7) The documentation that supports the model is good and simplifies the job of programming of the model.

Disadvantages

1) Only longitudinal variations in water properties are possible.

2) Uniform properties and instant mixing are assumed for each computational element.

3) Reaches must have constant properties along them.

4) Only steady-state hydraulics are capable of being modeled. Therefore, QUAL-II does not lend itself to unsteady-state modeling.

5) Although QUAL-II includes algae-nutrient interactions, the approach is somewhat simplified.

V. MATHEMATICAL MODELING OF WATER QUALITY

A) General

Dissolved oxygen modeling in both advective and estuarine systems is basically an attempt to keep an account of the major sources and sinks of oxygen in a system composed of a number of complex interacting subsystems (reaches), each with its own set of physical characteristics. The primary sources of oxygen are: 1) dissolved oxygen in tributary inflow waters, and 2) atmospheric reaeration. In some cases, the action of algae will, through photosynthesis, add oxygen to water. The primary sinks for oxygen are: 1) carbonaceous demands, 2) nitrogenous demands, 3) benthic demands, and 4) biological respiration.

Hydrodynamic factors fix the transport of oxygen and oxygen-demanding materials in and out of each element in the reach. In a river or stream, this is accomplished by advection. In an estuary, these factors consist of dispersive and advective components, freshwater flow and circulation. These parameters are significantly affected by the geometry and shape of each reach in the system.

B) Segmentation

One of the first steps in stream modeling is to divide the stream into reaches of constant characteristics. New segments or reaches may be established due to changes in cross-sectional areas, depth, width or velocity. Additional flow from tributaries or wastewater discharges may require that a new reach be established. A spatial variation from benthal demand or photosynthesis and respiration parameters may require additional segmentation. The Spring Creek model was segmented into thirteen reaches. The main stem consists of eleven reaches and the tributaries, Willow Creek and Panther Branch, consist of one reach each.

C) Hydraulics

After a stream has been segmented, it is necessary to specify the hydraulic and physical characteristics of each segment on the stream systems. Two equations are generally used to describe the hydraulic characteristics. The equations represent the relationship between discharge and velocity and discharge and depth. These relationships can be represented by exponential equations as shown below:

$$V = aQ^b$$

$$D = cQ^d$$

where:

V = mean velocity in a reach

Q = mean discharge in a reach

D = mean depth

a, b
c, d = coefficients

The velocity equation was formulated using data gathered by Farner & Winslow, Inc., during the February 1976 time-of-travel study on Spring Creek. The depth equation was formulated from flow, velocity, and width measurements along Cypress Creek.

D) Atmospheric Reaeration

The reaeration process is generally a function of temperature, stream geometry, and stream hydraulics. Several techniques and equations have been developed to estimate reaeration coefficients based on stream geometry and stream characteristics. The equations are generally in the form given by Streeter & Phelps (1925):

$$K_2 = \frac{c\,\bar{u}^n}{D^2}$$

where:

$\bar{u}$ = mean stream velocity

D = mean stream depth

c, n = constants for a particular stream

In the Spring Creek QUAL-II model, the O'Connor-Dobbins reaeration equation was used:

$$K_2\ (20°C) = \frac{12.84\ \bar{u}^{.5}}{D^{1.5}}$$

E) Carbonaceous Demands

Wastewater discharges from various types of treatment plants generally contain organic materials which will decompose in the presence of oxygen and certain bacteria. The bacteria which degrade the carbonaceous component of these organic materials are present in most waters and they begin the process of decomposition quickly. Carbonaceous oxygen demand is usually determined in the five-day biochemical oxygen demand test (BOD_5). In this test, the amount of oxygen consumed under aerobic conditions, at 20°C, is measured. It is frequently assumed that the ultimate carbonaceous demand is equal to 1.5 times the five-day oxygen demand. The BOD values input into the Spring Creek model are ultimate BOD values determined by multiplying the BOD_5 by 1.5.

Carbonaceous decay rates are usually determined from plotting the stream BOD values downstream of a discharger against the time-of-travel down the stream. The slope of the line is the decay rate. This method proved unacceptable for Spring Creek due to the large number of discharges which prevented isolating one BOD profile. The decay rates were adjusted so that the predicted BOD profiles matched the observed BOD profiles.

F) Nitrogenous Demands

Various nitrogen compounds exert an oxygen demand as they change from one form to another. These changes in form require the presence of a specific bacterial population. This population is not always available in sufficient

numbers to cause these changes, and under these circumstances, a delay or lag time is sometimes observed in the exertion of nitrogenous oxygen demand. The conversion of organic nitrogen to ammonia nitrogen is assumed to take place by hydrolysis and therefore exerts no oxygen demand. The conversion of ammonia nitrogen to nitrite nitrogen exerts an oxygen demand of 3.43 mg oxygen/mg nitrogen. The conversion of nitrite nitrogen to nitrate nitrogen exerts an oxygen demand of 1.14 mg oxygen/mg nitrogen.

The three nitrogenous decay rates were obtained from literature values. These rates were then adjusted to provide a reasonable fit between the predicted values and the observed values.

G) Benthal Demands

Bottom deposits, generally in the form of sludges discharged from municipal or industrial wastewater treatment plants, can exert an oxygen demand. These sludges accumulate below wastewater outfalls when stream velocities are not sufficient to keep solid particles in suspension. These sludges can exert an oxygen demand of from 5.0 to 1,000 milligrams of oxygen per square foot of bottom area per day. At higher treatment levels, the benthal demand will be reduced due to the reduction in discharged solids.

H) Photosynthesis/Respiration

The presence of algae can also have an effect on dissolved oxygen in surface waters. During periods of daylight, oxygen is produced as a by-product of photosynthesis. Oxygen is consumed during respiration. This complex system, involving both a source and sink of oxygen, frequently results in a diurnal variation in dissolved oxygen concentrations. The photosynthesis/respiration system can result in either a surplus or deficit of oxygen depending on a number of conditions including light intensities, available nutrients, and turbidity. The presence of algae is determined from chlorophyll a concentrations. No chlorophyll a was found during the Spring Creek surveys.

I) Coliforms

Because of the previously noted high chlorine residuals, the coliform data collected on Spring Creek proved unacceptable for coliform calibration. Therefore, a literature value of 0.1 $days^{-1}$ was chosen as the die-off rate.

J) Temperature Correction Factors

Many of the reactions which determine water quality in natural systems are dependent on temperature. This dependence is usually considered by changing the various rate constants according to the following equation:

$$K_T = K_{20}\,\theta^{(T-20)}$$

where K_T and K_{20} are rate constants at a temperature, T, and a 20° Centigrade, and θ is a temperature correction factor which depends on the reactions being considered. The following temperature correction factors are used:

Reaction	θ, Temperature Correction Factor
Atmospheric Reaeration	1.0159
Carbonaceous Decay	1.047
Nitrogenous Decay	1.047
Benthal Demand	1.065
Coliform Die-off	1.047

QUAL-II corrects all of above except benthal demand for temperature. The benthal demand must be corrected for temperature by hand before being input to the model.

VI. MODEL ANALYSIS

A calibration of the QUAL-II model for Spring Creek was made using data gathered by the City of Houston and TWQB self-reporting data. The input data is given in Attachment J. The calibration is shown in Attachment K. Good agreement is shown between the calculated and the observed values for dissolved oxygen and biochemical oxygen demand. Minor differences between calculated and observed values may be attributed to numerous causes including but not limited to: a possible lack of steady-state conditions during the survey, unaccounted non-point sources of pollution, the previously-mentioned chlorine toxicity and inhibition, the possible presence of algae, and sampling and measurement errors. Given the reasonably good

agreement shown in the calibration, the QUAL-II computer simulation model for Spring Creek, discussed in this report, can be used to evaluate a variety of alternative treatment schemes for Spring Creek.

VII. SENSITIVITY ANALYSIS

The output of any water quality simulation model depends on the hydraulics, rates, and waste loads which are input to the model. A list of the input values is given in Attachment J. It is useful to determine the sensitivity of this output to changes in input values. In the following sensitivity analysis, all but one parameter are held constant, and the remaining parameter value is varied by ± 20% about the values used in the calibrated model. The selection of a 20% variation is purely arbitrary. The following table lists changes in the dissolved oxygen at a critical point in the dissolved oxygen profile. The point chosen is at river mile 16 of Spring Creek and has a value of 6.40 mg/l in the calibrated model. The table shows only relative sensitivity of model output to changes in the input values.

Sensitivity of Model Output to Changes in Input Parameters. Dissolved Oxygen Concentrations at River Mile 16

Parameter	-20%*	+20%*	Difference
Stream Depth	6.79	5.98	0.81
Temperature	6.73	6.08	0.65
Effluent Flow	6.54	6.27	0.27
Benthal Demand	6.49	6.31	0.18
Effluent NH_3	6.46	6.33	0.13
Kl, BOD Decay Rate	6.47	6.34	0.13
Effluent BOD	6.46	6.34	0.12

Parameter	-20%*	+20%*	Difference
KNH3, NH_3 Decay Rate	6.44	6.37	0.07
Stream Velocity	6.42	6.38	0.04
Headwater Flow	6.38	6.41	0.03

*For temperature, ± 4°F

The table indicates that depth and temperature have the greatest relative effect on the calibrated model.

VIII. RECOMMENDATIONS FOR MODEL USE

It should be understood that the model calibration described in this report describes only a single set of conditions which existed in Spring Creek during a particular set of conditions (flow, waste loads, temperature, etc.). Very careful consideration must be given to any changes in the listed input conditions. A change in one parameter might easily necessitate some change in a related rate or coefficient. For this reason, any alternate treatment scheme which is sent to the Texas Water Quality Board for evaluation of receiving water quality impact must be adequately described. Attachment L at the end of this report should be used to describe these alternate treatment schemes.

Some general comments can be made concerning the alternative runs without knowing the specifics of each alternative treatment scheme. The following recommendations are meant only as a general statement of parameter changes.

Hydraulics - The coefficients and exponents will be considered acceptable for low flow conditions in the range of those used in calibrating this model. If large changes in flow condition occur, changes in the coefficients and exponents may be necessary.

Coefficients - During calibration, the coefficients for Reaches #1 and #2 were set to zero since no data was available to calibrate them. If alternative runs concerning these reaches are necessary, the coefficients for these reaches will be set equal to those in Reach #4 and the K_2 Option (K2OPT) set equal to 3. Otherwise, the beginning of Reach #3 will be considered as the headwater.

Because of the chlorine toxicity problems encountered during the surveys, there may be some justification in raising the CBOD decay rate (K1) and possibly the ammonia decay rate (CKNH3). However, any changes to these rates will have to be examined very carefully before adopting them.

The benthal rates are width and temperature dependent. Since no changes will be made in the hydraulic characteristics, the stream width will remain constant, and benthal rates need not be corrected for width. Unfortunately, at this time, the model does not correct benthal demands for temperature. When changing temperatures, the benthal demands must be changed using the following temperature correction:

$$B_T = B_{20}\ \theta^{T-20}$$

where:

B_T = Benthal rate at Temperature T

B_{20} = Benthal rate at 20°C

θ = Temperature correction factor (use 1.065)

T = Temperature (°C)

The following are the 20°C benthal rates:

Reach	Rate
3	950
4	950
5	635
6	315
7	635
8	315
9	635
10	635
11	510
12	510
13	510

Because of the high chlorine residuals found in the streams, coliform calibration was impossible. An assumed coliform decay rate of 0.1 is to be used in the model. If evidence suggests using some other rate, we will consider changing it.

Initial Conditions - Only the steady-state temperature need be specified. It will be input according to conditions being modeled.

Runoff Conditions - Runoff conditions will be input according to conditions being modeled.

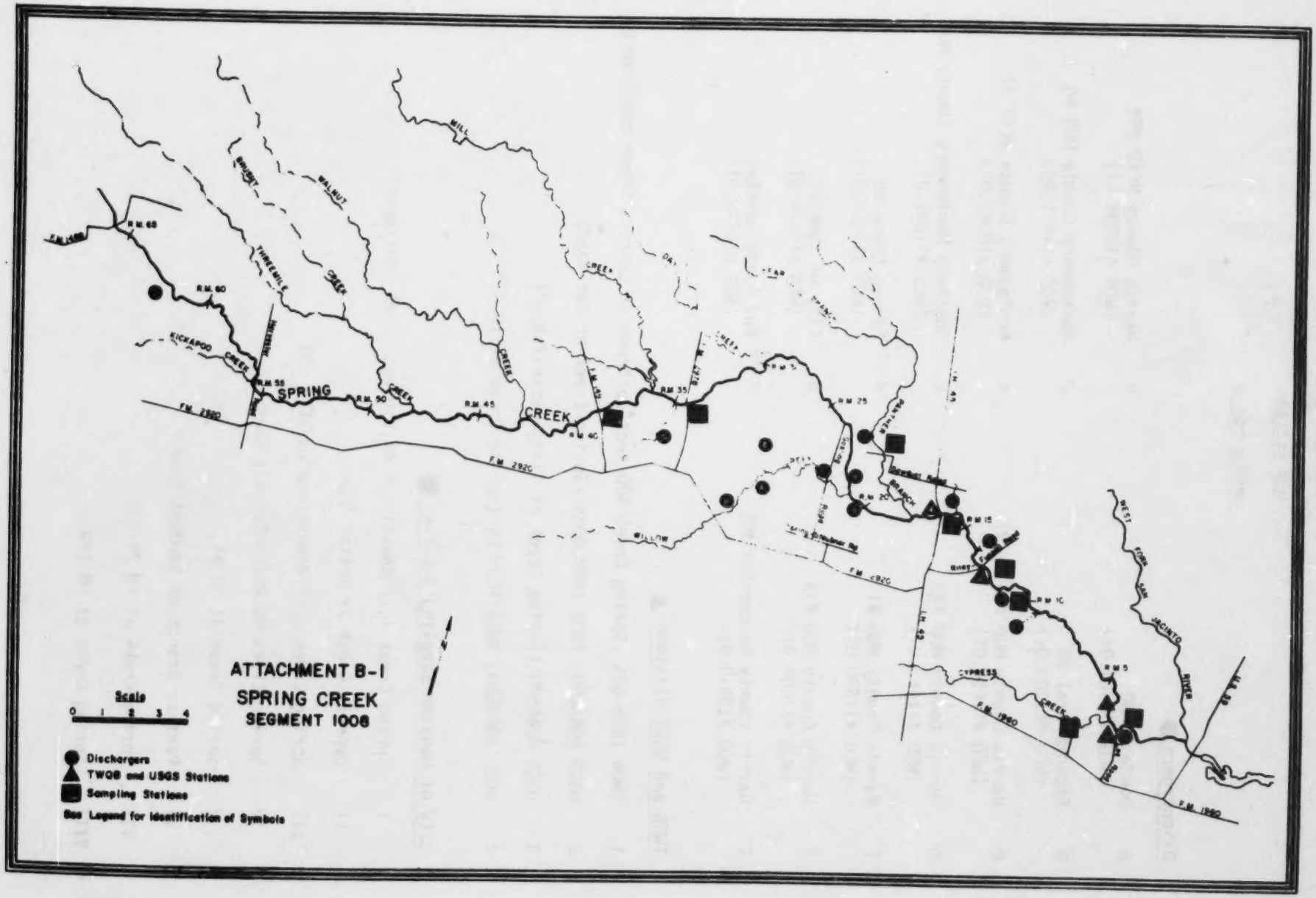
Headwater - Headwater conditions will be input according to conditions being modeled.

Waste Loads - Wasteloads will be input according to the alternative being modeled. BOD is ultimate BOD (1.5 x BOD_5). Organic nitrogen, ammonia, nitrite, and nitrate are entered as nitrogen (no oxygen equivalent factors necessary).

IX. SUMMARY

The staff of the Texas Water Quality Board has reviewed the data gathered in Spring Creek by the City of Houston. Using this data and monitoring data from the Texas Water Quality Board, a one-dimensional steady-state computer model has been calibrated for use by the Texas Water Quality Board and related planning agencies.

ATTACHMENTS


ATTACHMENT B-1
SPRING CREEK
SEGMENT 1008
Scale
0 1 2 3 4
Dischargers
TWQB and USGS Stations
Sampling Stations
See Legend for Identification of Symbols
SPRING
CREEK
KICKAPOO CREEK
THREEMILE CREEK
WALNUT CREEK
MILL CREEK
WILLOW
CYPRESS CREEK
WEST FORK SAN JACINTO RIVER
F.M. 2920
F.M. 1960
R.M. 65
R.M. 60
R.M. 55
R.M. 50
R.M. 45
R.M. 40
R.M. 35
R.M. 25
R.M. 20
R.M. 15
R.M. 10
R.M. 5

ATTACHMENT B-2

MAP LEGEND

SPRING CREEK

Dischargers ●

A Dowdell MUD (WCO #11404.01)

B Encanto Real UD (WCO #11303.01)

C Harris County MUD #26 & #27 (WCO #11406.01)

D Harris County MUD #82 (WCO #11463.01)

E Harris County MUD #1 (WCO #11630.01)

F Harris County MUD #35 (WCO #11604.01)

G Harris County Norchester MUD (WCO #10910.01)

H Harris County WCID #92 (WCO #10908.01)

J Montgomery County MUD #6 (WCO #11401.01)

K Montgomery County WCID #1 (WCO #10857.01)

L Southern Montgomery County MUD (WCO #11001.01)

M Spring Creek UD (WCO #11574.01)

N City of Tomball (WCO #10616.01)

P Bud Adams Ranches (WCO #20740.01)

TWQB and USGS Stations ▲

1 TWQB 1008.005 (Spring Creek 600 feet upstream of Cypress Creek confluence)

2 USGS 8068600; TWQB 1008.0025 (Spring Creek at Lee Road)

3 USGS 8068520 (Spring Creek at Riley-Fussell Road)

4 USGS 8068500; TWQB 1008.01 (Spring Creek at IH 45)

City of Houston Sampling Stations ■

I Spring Creek just downstream of Cypress Creek confluence

II Cypress Creek at Tettar Road

III Spring Creek just downstream of WCID #92

IV Spring Creek at Riley-Fussell Road

V Spring Creek at IH 45

VI Panther Branch at Sawdust Road

VII Spring Creek at FM 2978

VIII Spring Creek at FM 149

ATTACHMENT C

TWQB STREAM MONITORING DATA
SPRING CREEK

STATION NO. 1000.0025 — STATION LOCATION: AT LEE ROAD IN HOUSTON

SAMPLE DATE	TIME	DEPTH (FT.)	SOURCE AGENCY	STREAM FLOW CFS	WATER TEMP FAHR	FEC COLI /100ML	DO MG/L	BOD 5 DAY MG/L	NH3-N TOTAL MG/L	T PO4 PO4 MG/L	CHLRPHYL A MG/L	PH SU	RESIDUE TOT NFLT MG/L	NO3-N TOTAL MG/L	CHLORIDE CL MG/L	SULFATE SO4 MG/L	RESIDUE DISS-SOL COND.MG/L	CNDUCTVY AT 25C MICROMHO	TURB JKSN JTU
08/07/75	1135	1.0	TWQB		86.0	3200.*	6.8	2.0	1.000	.00	.001		103.	.20		13.	160.	170.	140.0
01/12/76	1425	1.0	TWQB		62.0	320.	12.0	1.0	.550	.00	.000		11.	.94	67.	16.		500.	

STATION SUMMARY

	WATER TEMP FAHR	FEC COLI /100ML	DO MG/L	BOD 5 DAY MG/L	NH3-N TOTAL MG/L	T PO4 PO4 MG/L	CHLRPHYL A MG/L	PH SU	RESIDUE TOT NFLT MG/L	NO3-N TOTAL MG/L	CHLORIDE CL MG/L	SULFATE SO4 MG/L	RESIDUE DISS-SOL COND.MG/L	CNDUCTVY AT 25C MICROMHO	TURB JKSN JTU
AVERAGE	74.0		9.4	1.5	.775	.00	.001		57.	.57	67.	14.	160.	335.	140.0
GEOMETRIC MEAN		1012.													
MAXIMUM	86.0	3200.	12.0	2.0	1.000	.00	.001		103.	.94	67.	16.	160.	500.	140.0
MINIMUM	62.0	320.	6.8	1.0	.550	.00	.000		11.	.20	67.	13.	160.	170.	140.0
SECOND HIGHEST SAMPLE	62.0	320.	6.8	1.0	.550	.00	.000		11.	.20		13.		170.	
SECOND LOWEST SAMPLE	86.0	3200.	12.0	2.0	1.000	.00	.001		103.	.94		16.		500.	
NUMBER OF SAMPLES	2	2	2	2	2	2	2		2	2	1	2	1	2	1

SEGMENT STANDARDS — EFFECTIVE DATE: 10/25/73 — DEPTH: 1.0

	WATER TEMP FAHR	FEC COLI /100ML	DO MG/L	BOD 5 DAY MG/L	NH3-N TOTAL MG/L	T PO4 PO4 MG/L	CHLRPHYL A MG/L	PH SU	RESIDUE TOT NFLT MG/L	NO3-N TOTAL MG/L	CHLORIDE CL MG/L	SULFATE SO4 MG/L	RESIDUE DISS-SOL COND.MG/L	CNDUCTVY AT 25C MICROMHO	TURB JKSN JTU
MAXIMUM	90.0	2000.						8.50			80.	40.	300.		
MINIMUM			5.0					6.50							

AN ASTERISK (*) DENOTES A MEASUREMENT THAT IS NOT WITHIN STANDARDS.

STATION NO. 1008.0050 — STATION LOCATION: 600 FT UPSTREAM FROM CONFLUENCE WITH CYPRESS CREEK ABOUT 4 MI. NW OF HUMBLE

SAMPLE DATE	TIME	DEPTH (FT.)	SOURCE AGENCY	STREAM FLOW CFS	WATER TEMP FAHR	FEC COLI /100ML	DO MG/L	BOD 5 DAY MG/L	NH3-N TOTAL MG/L	T PO4 PO4 MG/L	CHLRPHYL A MG/L	PH SU	RESIDUE TOT NFLT MG/L	NO3-N TOTAL MG/L	CHLORIDE CL MG/L	SULFATE SO4 MG/L	RESIDUE DISS-SOL COND.MG/L	CNDUCTVY AT 25C MICROMHO	TURB JKSN JTU
06/25/74	1045	1.0	TWQB	32.5	89.0	220.	9.5		.000	.90	.370		24.	.07	70.	12.		352.	

STATION SUMMARY

	WATER TEMP FAHR	FEC COLI /100ML	DO MG/L	BOD 5 DAY MG/L	NH3-N TOTAL MG/L	T PO4 PO4 MG/L	CHLRPHYL A MG/L	PH SU	RESIDUE TOT NFLT MG/L	NO3-N TOTAL MG/L	CHLORIDE CL MG/L	SULFATE SO4 MG/L	RESIDUE DISS-SOL COND.MG/L	CNDUCTVY AT 25C MICROMHO	TURB JKSN JTU
AVERAGE	89.0		9.5		.000	.90	.370		24.	.07	70.	12.		352.	
GEOMETRIC MEAN		220.													
MAXIMUM	89.0	220.	9.5		.000	.90	.370		24.	.07	70.	12.		352.	
MINIMUM	89.0	220.	9.5		.000	.90	.370		24.	.07	70.	12.		352.	
SECOND HIGHEST SAMPLE															
SECOND LOWEST SAMPLE															
NUMBER OF SAMPLES	1	1	1		1	1	1		1	1	1	1		1	

SEGMENT STANDARDS — EFFECTIVE DATE: 10/25/73 — DEPTH: 1.0

	WATER TEMP FAHR	FEC COLI /100ML	DO MG/L	BOD 5 DAY MG/L	NH3-N TOTAL MG/L	T PO4 PO4 MG/L	CHLRPHYL A MG/L	PH SU	RESIDUE TOT NFLT MG/L	NO3-N TOTAL MG/L	CHLORIDE CL MG/L	SULFATE SO4 MG/L	RESIDUE DISS-SOL COND.MG/L	CNDUCTVY AT 25C MICROMHO	TURB JKSN JTU
MAXIMUM	90.0	2000.						8.50			80.	40.	300.		
MINIMUM			5.0					6.50							

AN ASTERISK (*) DENOTES A MEASUREMENT THAT IS NOT WITHIN STANDARDS.

STATION NO. 1008.0100 — STATION LOCATION: PETDGE BR I. H. 45, 20 MILES NORTH OF HOUSTON

SAMPLE DATE	TIME	DEPTH (FT.)	SOURCE AGENCY	STREAM FLOW CFS	WATER TEMP FAHR	FEC COLI /100ML	DO MG/L	BOD 5 DAY MG/L	NH3-N TOTAL MG/L	T PO4 PO4 MG/L	CHLORPHYL A MG/L	PH SU	RESIDUE TOT NFLT MG/L	NO3-N TOTAL MG/L	CHLORIDE CL MG/L	SULFATE SO4 MG/L	RESIDUE DISS-SOL CON.MG/L	CNDUCTVY AT 25C MICROMHO	TURB JKSN JTU
10/26/71		1.0		16	67.0		10.5	1.0											
11/29/71		1.0		12	59.0		6.6	2.7							51.	6.		282.	35.0
12/29/71		1.0		124	53.0		8.6	2.9							91.*	6.		556.	25.0
01/24/72		1.0		14	69.0		11.2								47.	3.		217.	
02/18/72	1020	1.0		22	54.0		8.8								79.	5.		730.	
03/29/72	0935	1.0		58	67.0		6.0	6.5	.160	4.07	.010	7.60	8.	.62	35.	12.	210.		20.0
04/25/72	1055	1.0		49	68.0		7.2					7.20					125.	240.	100.0
05/08/72	0955	1.0		1970	67.0		5.6					7.20					125.		200.0
06/19/72	0940	1.0		248	74.0	750.	5.6	3.0	.070	3.77	.010	7.20*					50.		55.0
07/13/72	0935	1.0		14	76.0		6.0						120.	.05	17.	2.		605.	130.0
08/22/72	0945	1.0		23	78.0		5.2					6.90					350.*		
09/07/72	1015	1.0		9.0	79.0	110000.*	4.0	3.3	.140	1.96	.011	7.10							15.0
10/16/72	1035	1.0		7.5	77.0		5.4						56.	.48	6.	2.		300.	60.0
11/27/72	0935	1.0		100	76.0		5.2					7.00					750.*		75.0
12/19/72	0940	1.0		30	73.0		4.0					7.10					350.*		70.0
01/11/73	0935	1.0		497	67.0		8.0					7.00					200.		60.0
02/15/73	1200	1.0		2600	52.0	11000.*	6.4	4.0	.170	1.23	.011	7.80					125.		70.0
03/26/73	1705	1.0		4400	62.0		5.6	1.0	.000	.45	.003		150.	.59	14.	1.		200.	80.0
04/12/73	1045	1.0		243	66.0		7.6	2.0	.060	.45	.010		125.	.00	4.	4.		445.	
05/08/73	1130	1.0		450	70.0		5.8	3.0	.140	.47	.009		9.	.09	17.	10.		126.	
06/07/73	1025	1.0		809	73.0	11000.*	5.8	3.0	.320	1.0	.009		11.	.25	31.	6.		98.	
07/30/73	1040	1.0		45	81.0		5.6					6.90	11.	.09	29.	34.		154.	
08/08/73	0945	1.7		150	76.0		4.6	2.0	.170	1.23	.002		170.				155.		90.0
09/18/73	1015	1.0	TWQB	61	73.0	4400.*	4.2	1.0	1.770	3.94			29.	.19	41.	10.		300.	75.0
10/18/73	0930	1.0	TWQB	433.	65.0		6.0					6.70						183.	50.0
11/08/73	0930	1.0	TWQB	176	68.0		7.4					6.70					100.		60.0
12/06/73	1000	1.0	TWQB	586	55.0	300.*	9.3										100.		50.0
01/07/74	1000	1.0	TWQB	205	60.0		9.9		.200	4.72		6.90	104.	.12	28.	26.		125.	50.0
02/12/74	1020	1.0	TWQB	105	57.0	440.	9.9										200.		55.0
03/07/74	0950	1.0	TWQB	63	65.0	40.	7.2		.700	9.08			36.	.18	51.	10.		230.	50.0
04/08/74	1005	1.0	TWQB	53	67.0	47000.*	8.4		.000	.35			16.	.21	70.	3.		310.	40.0
05/13/74	0950	1.0	TWQB	400	72.0		6.5			.49	.000		199.	.43	70.	5.		320.	
06/19/74	0930	1.0	TWQB	27	78.0	1.0.	6.4		.100	.76	.016	7.70					125.		80.0
07/11/74	1000	1.0	TWQB	14	78.0		6.4						82.	.28	70.	5.		362.	
08/20/74	1100	1.0	TWQB	7.5	79.0		6.5					7.10					175.		70.0
09/16/74	0940	1.0	TWQB	4050	74.0	160.	6.1		1.000	.81		7.00					210.		30.0
10/10/74	0950	1.0	TWQB	28	68.0		7.9					7.40	35.	1.00	4.	9.		30.	
11/21/74	0920	1.0	TWQB	102	61.0		7.4					7.30					180.		20.0
12/04/74	1045	1.0	TWQB	175	49.0	140.	10.5		1.700	6.27			18.	.13	31.	.5.	195.		30.0
01/09/75	0930	1.0	TWQB	124	56.0		4.7					7.00						300.	
02/11/75	0925	1.0	TWQB	140	55.0		9.4					7.20					200.		70.0
03/05/75	1215	1.0	TWQB	76	55.0	70.	10.4		1.700	.81			17.	.29	64.	7.	150.		60.0
04/02/75	0925	1.0	TWQB	62	65.0		8.6					7.20					239.	332.	
05/06/75	1045	1.0	TWQB	121	75.0	10.	6.5	2.6	1.170	1.74							225.		40.0
06/17/75	1015	1.0	TWQB	31	77.0	210.	7.0		1.700	.00	.000		43.	.15	27.	6.	155.	180.	
12/03/75	1225	1.0	TWQB		54.0	10.	11.0		1.700	.07	.006		44.	.35	62.	6.	210.	300.	
03/10/76	1045	1.0	TWQB		59.0		8.9		.120	.00	.027		9.	.37	83.*	5.		400.	
06/09/76	1020	1.0	TWQB		74.0	190.	6.8		.060	.06	.000		115.	.13	58.	20.	188.	230.	
09/13/76	0950	1.0	TWQB		79.9	430.	7.0	1.0	.110	.83	.006		41.	.20	37.	5.	155.	230.	
12/13/76	0935	1.0	TWQB		51.1	2200.*	10.2		.030	.63	127.000		26.	.61	92.*		267.	300.	
													42.	.01	13.	17.		95.	95.0

STATION SUMMARY

	STREAM FLOW CFS	WATER TEMP FAHR	FEC COLI /100ML	DO MG/L	BOD 5 DAY MG/L	NH3-N TOTAL MG/L	T PO4 PO4 MG/L	CHLORPHYL A MG/L	PH SU	RESIDUE TOT NFLT MG/L	NO3-N TOTAL MG/L	CHLORIDE CL MG/L	SULFATE SO4 MG/L	RESIDUE DISS-SOL CON.MG/L	CNDUCTVY AT 25C MICROMHO	TURB JKSN JTU
AVERAGE		66.4		7.4	2.6	.360	1.82	7.478		74.	.26	49.	9.	204.	281.	61.6
GEOMETRIC MEAN			279.													
MAXIMUM		81.0	4700.	11.2	6.5	1.000	9.08	127.000	7.60	198.	1.00	92.	34.	750.	730.	200.0
MINIMUM		48.0	10.	4.0	1.0	.000	.00	.000	6.20	9.	.00	4.	1.	50.	30.	15.0
SECOND HIGHEST SAMPLE		79.0	440.	11.0	4.0	1.000	6.27	.027	7.60	175.	.62	68.	26.	350.	605.	130.0
SECOND LOWEST SAMPLE		56.0	40.	4.0	1.0	.000	.00	.000	6.70	16.	.01	4.	2.	100.	95.	20.0
NUMBER OF SAMPLES		56	18	50	19	29	29	17	21	25	24	27	27	27	29	32

EFFECTIVE DATES: 10/25/73
DEPTH: 1.0

SEGMENT STANDARDS

	STREAM FLOW CFS	WATER TEMP FAHR	FEC COLI /100ML	DO MG/L	BOD 5 DAY MG/L	NH3-N TOTAL MG/L	T PO4 PO4 MG/L	CHLORPHYL A MG/L	PH SU	RESIDUE TOT NFLT MG/L	NO3-N TOTAL MG/L	CHLORIDE CL MG/L	SULFATE SO4 MG/L	RESIDUE DISS-SOL CON.MG/L	CNDUCTVY AT 25C MICROMHO	TURB JKSN JTU
MAXIMUM		90.0	25.0.						8.50			80.	40.	300.		
MINIMUM				5.0					6.50							

AN ASTERISK (*) DENOTES A MEASUREMENT THAT IS NOT WITHIN STANDARDS.

ATTACHMENT D-1

SPRING CREEK DIURNAL FIELD MEASUREMENTS
FEBRUARY 3, 1976 CITY OF HOUSTON SURVEY

Station Location	Dissolved Oxygen (mg/l) Range	Dissolved Oxygen (mg/l) Average	Temperature (^{o}F) Range	Temperature (^{o}F) Average	Average pH	Average Conductivity (μmhos/cm)
Below Cypress Creek Confluence	7.0-13.0	9.3	56-64	59	6.9	427
Below WCID #92	--------	---	50-61	57	7.1	328
Riley-Fussell Road	5.0-10.8	8.7	54-60	57	7.1	309
IH 45	4.2- 9.2	5.8	50-56	55	7.1	423
FM 2978	7.3-11.0	8.5	51-58	55	7.1	0.19
FM 149	6.6- 8.7	7.6	52-55	54	7.0	0.20
In Cypress Creek at Tettar Road	6.5- 8.5	8.5	53-56	55	7.1	626
In Panther Branch at Sawdust Road	4.0- 8.0	5.0	55-60	57	7.1	481

ATTACHMENT D-2

SPRING CREEK LABORATORY ANALYSES
FEBRUARY 3, 1976 CITY OF HOUSTON SURVEY

Station Location	BOD_5 (mg/l)	Org-N (mg/l)	NH_3 (mg/l)	NO_2 (mg/l)	NO_3 (mg/l)	Total P (mg/l)	Chloro a (mg/l)	TSS (mg/l)	TDS (mg/l)
Below Cypress Creek Confluence	2	1.05	0.8	0.07	0.70	0.8	0	5	285
Below WCID #92	2	0.70	4.2	0.05	0.72	0.6	0	5	306
Riley-Fussell Road	2	0.98	2.1	0.04	0.46	0.5	0	5	293
IH 45	3	0.84	1.5	0.06	0.49	0.2	0	5	326
FM 2978	1	1.05	0.1	0.01	0.59	0.4	0	6	305
FM 149	1	0.56	0.3	0.01	0.29	0.4	0	5	321
In Cypress Creek at Tettar Road	7	4.40	0.8	0.40	3.76	5.9	0	7	458
In Panther Branch at Sawdust Road	3	1.20	0.6	0.03	5.33	1.2	0	8	370

ATTACHMENT D-3

SPRING CREEK DIURNAL COLIFORM ANALYSES
FEBRUARY 3, 1976 CITY OF HOUSTON SURVEY

Station Location	Total Coliform (MPN/100 ml) Range	Total Coliform (MPN/100 ml) Log Average	Fecal Coliform (MPN/100 ml) Range	Fecal Coliform (MPN/100 ml) Log Average
Below Cypress Creek Confluence	490- 1,400	695	<20- 80	32
Below WCID #92	270- 700	510	50- 90	>1
Riley-Fussell Road	2,300-35,000	8,600	50-13,000	319
IH 45	790- 1,300	1,040	60- 130	82
FM 2978	330- 630	467	50- 80	58
FM 149	790- 1,100	1,140	220- 460	322
In Cypress Creek at Tettar Road	2,100- 3,500	2,530	130- 170	155
In Panther Branch at Sawdust Road	20- 260	75	<20	<20

ATTACHMENT E-1

SPRING CREEK DIURNAL FIELD MEASUREMENTS
AUGUST 4, 1976 CITY OF HOUSTON SURVEY

Station Location	Dissolved Oxygen (mg/l) Range	Dissolved Oxygen (mg/l) Average	Temperature (°F) Range	Temperature (°F) Average	Average pH	Average Conductivity (μmhos/cm)
Below Cypress Creek Confluence	6.1-12.6	7.6	76-93	81	6.0	554
Below WCID #92	5.0-10.0	8.2	76-93	84	6.4	0.28
Riley-Fussell Road	5.4-10.0	7.4	76-88	82	6.4	0.26
IH 45	4.5- 8.0	6.2	75-84	79	6.4	176
FM 2978	3.2- 6.5	4.6	76-82	81	6.7	318
FM 149	3.4- 5.2	3.8	74-80	81	6.8	409
In Cypress Creek at Tettar Road	4.9-12.4	9.0	81-87	82	6.8	532
In Panther Branch at Sawdust Road	5.1- 7.5	6.0	75-82	79	6.8	369

ATTACHMENT E-2

SPRING CREEK LABORATORY ANALYSES
AUGUST 4, 1976 CITY OF HOUSTON SURVEY

Station Location	BOD_5 (mg/l)	Org-N (mg/l)	NH_3 (mg/l)	NO_2 (mg/l)	NO_3 (mg/l)	Total P (mg/l)	Chloro a (mg/l)	TSS (mg/l)	TDS (mg/l)
Below Cypress Creek Confluence	1.95	1.3	0.0	0.10	0.35	0.48	0	37	374
Below WCID #92	4.10	1.3	0.4	0.08	1.33	1.14	0	51	272
Riley-Fussell Road	4.65	1.0	0.5	----	----	0.48	-	--	---
IH 45	2.40	0.6	0.3	0.05	0.49	0.33	0	50	258
FM 2978	0	1.0	0.0	0.02	0.77	0.65	0	10	255
FM 149	1.05	0.8	0.0	0.02	0.29	0.32	0	31	317
In Cypress Creek at Tettar Road	4.80	1.5	0.8	0.54	2.93	2.61	0	29	305
In Panther Branch at Sawdust Road	1.50	1.3	0.14	0.20	16.10	4.40	0	38	555

ATTACHMENT E-3

SPRING CREEK DIURNAL COLIFORM ANALYSES
August 4, 1976 CITY OF HOUSTON SURVEY

Station Location	Total Coliform (MPN/100 ml) Range	Total Coliform (MPN/100 ml) Log Average	Fecal Coliform (MPN/100 ml) Range	Fecal Coliform (MPN/100 ml) Log Average
Below Cypress Creek Confluence	1,300- 2,100	1,563	<200- 400	252
Below WCID #92	500- 7,000	1,409	<200- 4,900	581
Riley-Fussell Road	7,900-49,000	17,136	3,100- 4,900	4,206
IH 45	1,600- 1,700	1,666	<200- 800	317
FM 2978	1,100- 3,300	2,113	200- 1,400	383
FM 149	500- 7,900	1,632	200- 1,100	479
In Cypress Creek at Tettar Road	700- 1,700	941	<200- 500	271
In Panther Branch at Sawdust Road	17,000-70,000	33,990	17,000-70,000	30,136

ATTACHMENT F

EXISTING WASTE LOADS ON SPRING CREEK

		WCO No.	River[a] Mile		Flow[b] (MGD)	BOD_5[b] (mg/l)	NH_3[c] (mg/l)	BOD_5 (#/day)	L_p (#/day)	N_p (#/day)	Total (#/day)
A	Dowdell MUD	11404.01	20.7 (6.8)	Existing	0.036	2.4	8.0	1	1	11	12
				Permitted	0.300	20.0	----	---	---	---	---
B	Encanto Real UD	11303.01	20.3	Existing	Operational November 1976.			---	---	---	---
				Permitted	0.300	10.0	----	25	38	---	---
C	Harris County MUD #26 & #27	11406.01	1.7	Existing	Not yet constructed.		----	---	---	---	---
				Permitted	0.100	20.0	----	17	25	---	---
D	Harris County MUD #32	11463.01	9.3 (1.4)	Existing	0.029	9.2	6.3	2	3	7	10
				Permitted	0.050	20.0	----	8	13	---	---
E	Harris County MUD #1	11630.01	20.7 (5.8)	Existing	Not yet constructed.		----	---	---	---	---
				Permitted	0.100	10.0	----	8	13	---	---
F	Harris County MUD #35	11604.01	20.7 (5.3)	Existing	Not yet constructed.		----	---	---	---	---
				Permitted	0.437	10.0	----	36	55	---	---
G	Harris County Norchester MUD	10910.01	20.7 (1.7)	Existing	0.198	3.3	2.7	5	8	20	28
				Permitted	3.050	20.0	----	509	763	---	---

		WCO No.	River[a] Mile		Flow[b] (MGD)	BOD_5[b] (mg/l)	NH_3[c] (mg/l)	BOD_5 (#/day)	L_o (#/day)	L_c (#/day)	Total (#/day)
H	Harris County WCID #92	10908.01	11.5								
				Existing	0.187	3.1	1.4	5	7	10	17
				Permitted	0.500	20.0	----	83	125	---	---
J	Montgomery Co. MUD #6	11401.01	17.7 (3.8)								
				Existing	0.125	2.6	8.0	3	4	38	42
				Permitted	1.500	5.0	----	63	94	---	---
K	Montgomery Co. WCID #1	10857.01	21.7								
				Existing	0.260	11.3	8.9	25	37	88	125
				Permitted	0.300	20.0	----	50	75	---	---
L	Southern Montgomery Co. MUD	11001.01	15.7 (0.3)								
				Existing	0.802	16.4	15.3	110	165	468	633
				Permitted	2.000	20.0	----	334	500	---	---
M	Spring Creek UD	11574.01	13.6 (1.1)								
				Existing	0.072	8.7	14.2	5	8	39	47
				Permitted	0.070	20.0	----	12	18	---	---
N	City of Tomball	10616.01	34.8 (2.2)								
				Existing	0.235	5.6	0.7	11	16	6	22
				Permitted	0.750	20.0	----	125	188	---	---
P	Bud Adams Ranches	20740.01									
				Existing	No Discharge Permit.		----	---	---	---	---
				Permitted	No Discharge Permit.		----	---	---	---	---

[a] Parentheses indicate river mile up the tributary.

[b] Based on average TWQB self-reporting data from January 1976 through September 1976.

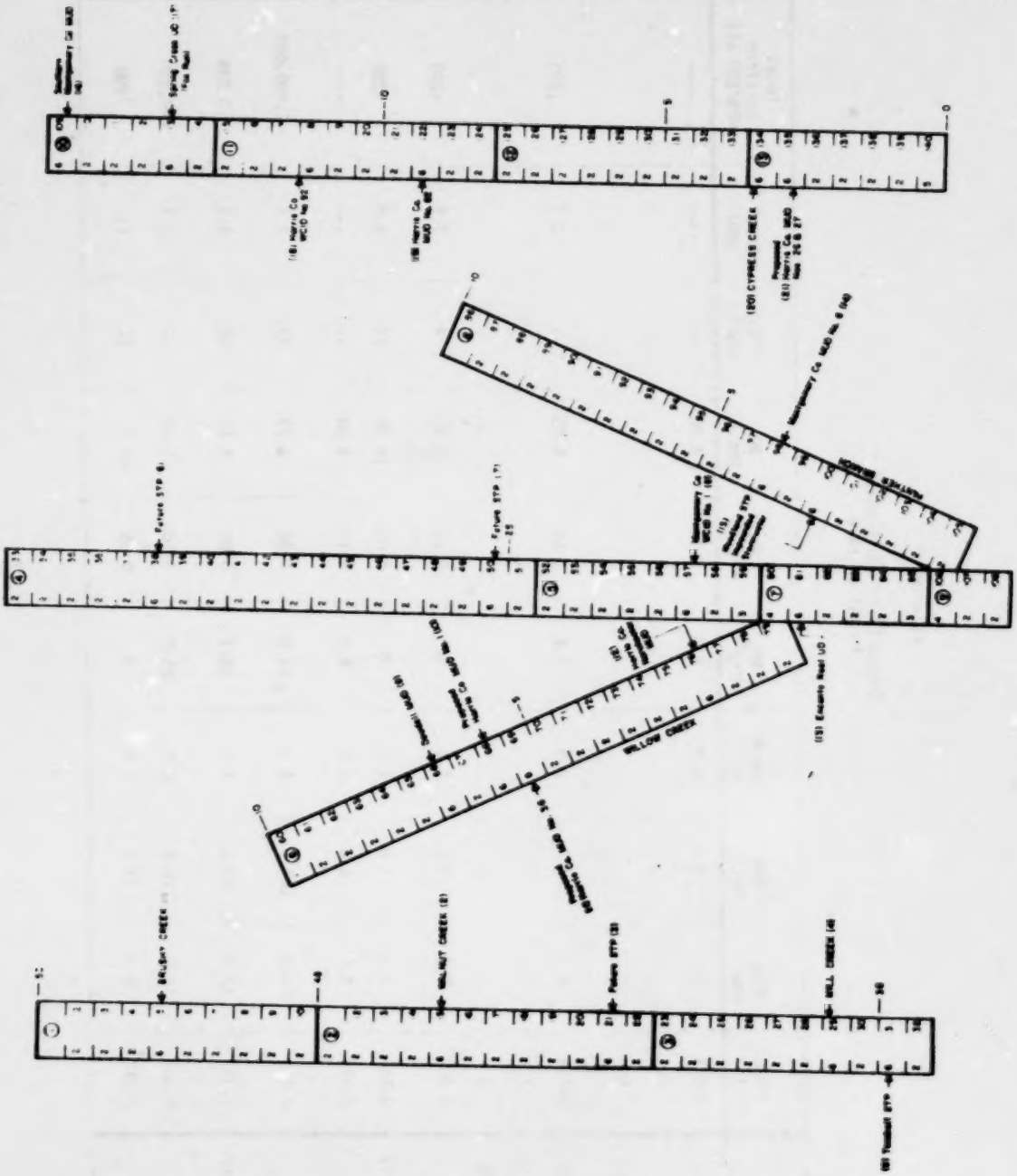
[c] Based on return flow data and field measurements.

ATTACHMENT G

SPRING CREEK WASTE LOADS
AUGUST 4, 1976

Discharger	Flow (cfs)	BOD_5 (mg/l)	BOD_L (mg/l)	Org-N (mg/l)	NH_3 (mg/l)	NO_2 (mg/l)	NO_3 (mg/l)	TSS (mg/l)	Total P (mg/l)	Total Coliform (MPN/100 ml)	Fecal Coliform (MPN/100 ml)
Dowdell MUD	0.094	3.0	4.5	9.0	8.0	0.10	4.00	--	----	----	----
Encanto Real UD	0										
Harris Co. MUD #26 & #27	0										
Harris Co. MUD #82	0.034	4.0	6.0	2.3	3.4	0.65	5.05	--	7.2	<200	<200
Harris Co. MUD #1	0										
Harris Co. MUD #35	0										
Harris Co. Norchester MUD	0.309	2.0	3.0	1.3	0	0.25	6.50	4	7.6	<200	<200
Harris Co. WCID #92	0.317	2.0	3.0	1.3	0	0.05	14.70	24	6.8	<200	<200
Montgomery Co. MUD #6	0.193	4.0	6.0	9.0	8.0	0.10	4.00	--	---	----	----
Montgomery Co. WCID #1	0.394	96.0	144.0	4.3	11.5	0.56	0.23	48	4.6	≥2,400,000	≥2,400,000
Southern Montgomery Co. MUD	1.323	17.0	25.5	4.1	16.3	0.06	4.10	28	4.2	3,039	408
Spring Creek UD	0.108	151.0	226.5	6.7	25.0	0.10	1.00	--	10.4	249,610	104,830
City of Tomball	0.342	9.0	13.5	1.4	0	0.05	18.05	11	5.7	<200	<200

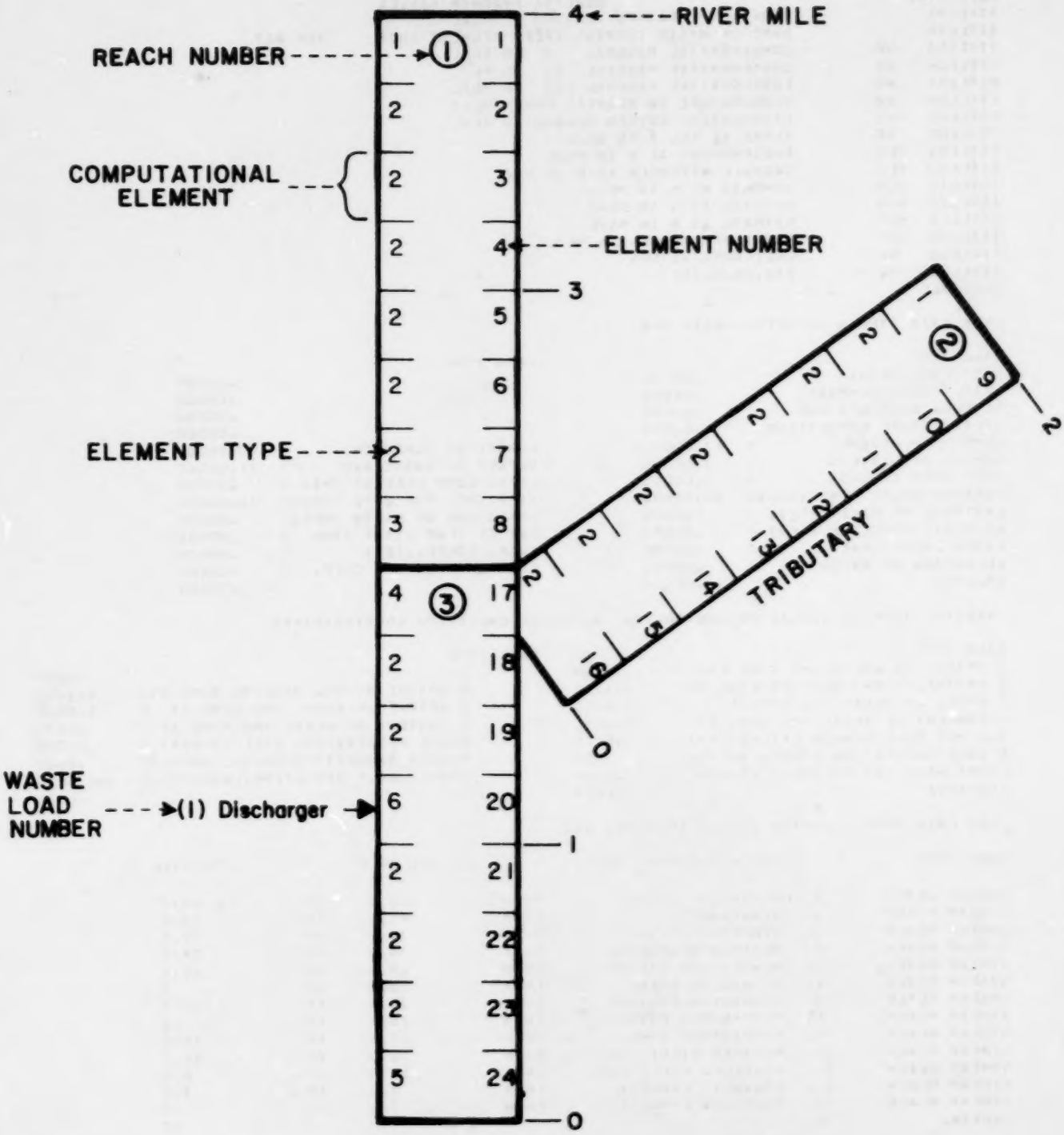
ATTACHMENT H-1
SPRING CREEK SCHEMATIC



ATTENTION

AS NOTED IN THE NTIS ANNOUNCEMENT, PORTIONS OF THIS REPORT ARE NOT LEGIBLE. HOWEVER, IT IS THE BEST REPRODUCTION AVAILABLE FROM THE COPY SENT TO NTIS.

ATTACHMENT H-2
SCHEMATIC EXPLANATION



ATTACHMENT J

SPRING CREEK
QUAL-II MODEL INPUT

```
$$$ (PROBLEM TITLES) $$$

CARD TYPE                                  QUAL-II PROGRAM TITLES
TITLE01                  TWDB/WRE EXPANDED VERSION OF QUAL-I
TITLE02                  NAME OF BASIN =SPRING CREEK SEGMENT 1008      RUN #17
TITLE03    NO            CONSERVATIVE MINERAL   I  IN MG/L
TITLE04    NO            CONSERVATIVE MINERAL  II  IN MG/L
TITLE05    NO            CONSERVATIVE MINERAL III  IN MG/L
TITLE06    NO            TEMPERATURE IN DEGREES FAHRENHEIT
TITLE07   YES            BIOCHEMICAL OXYGEN DEMAND IN MG/L
TITLE08    NO            ALGAE AS CHL A IN UG/L
TITLE09   YES            PHOSPHOROUS AS P IN MG/L
TITLE10   YES            ORGANIC NITROGEN AS N IN MG/L
TITLE11   YES            AMMONIA AS N IN MG/L
TITLE12   YES            NITRITE AS N IN MG/L
TITLE13   YES            NITRATE AS N IN MG/L
TITLE14   YES            DISSOLVED OXYGEN IN MG/L
TITLE15    NO            COLIFORMS AS MPN
TITLE16    NO            RADIONUCLIDE
ENDTITLE

$$$ DATA TYPE 1 (CONTROL DATA) $$$

CARD TYPE                                  CARD TYPE
LIST DATA INPUT                .00000                                  .00000
WRITE FINAL SUMMARY            .00000                                  .00000
NO FLOW AUGMENTATION           .00000                                  .00000
STEADY STATE SIMULATION        .00000                                  .00000
NUMBER OF REACHES        =   13.00000   NUMBER OF JUNCTIONS      =   2.00000
NUM OF HEADWATERS        =    3.00000   NUMBER OF WASTELOADS     =  21.00000
TIME STEP (HOURS)        =     .00000   LNTH. COMP ELEMENT (MI)  =    .50000
MAXIMUM ROUTE TIME (HRS)=   30.00000   TIME INC. FOR RPT2 (HRS)=  30.00000
LATITUDE OF BASIN (DEG) =     .00000   LONGITUDE OF BASIN (DEG)=    .00000
STANDARD MERIDIAN (DEG) =     .00000   DAY OF YEAR START TIME   =    .00000
EVAP. COEFF.,(AE)        =     .00000   EVAP. COEFF.,(BE)        =    .00000
ELEVATION OF BASIN       =     .00000   DUST ATTENUATION COEF.   =    .00000
ENDATA1                        .00000                                  .00000

$$$DATA TYPE 1A (ALGAE PRODUCTION AND NITROGEN OXIDATION CONSTANTS)$$$

CARD TYPE                                  CARD TYPE
O UPTAKE BY ORG N (MG O/MG N)  =     .0000                                  .0000
O UPTAKE BY NH3 OXID(MG O/MG N)=    3.4300   O UPTAKE BY NO2 OXID(MG O/MG N)=   1.1400
O PROD. BY ALGAE (MG O/MG A)   =    1.6000   O UPTAKE BY ALGAE (MG O/MG A)  =   1.9500
N CONTENT OF ALGAE (MG N/MG A) =     .0850   P CONTENT OF ALGAE (MG P/MG A) =    .0130
ALG MAX SPEC GROWTH RATE(1/DAY)=    2.0000   ALGAE RESPIRATION RATE (1/DAY) =    .1000
N HALF SATURATION CONST. (MG/L)=     .3000   P HALF SATURATION CONST. (MG/L)=    .0400
LIGHT HALF SAT CONST(LNGLY/MIN)=     .0300   TOTAL DAILY RADIATION(LANGLEYS)=  300.0000
ENDATA1A                             .0000                                  .0000

$$$ DATA TYPE 2 (REACH IDENTIFICATION) $$$

CARD TYPE          REACH ORDER AND IDENT                  R. MILE              R. MILE

STREAM REACH     1.  RCHSPRING SOURCE        FROM        50.0    TO          45.0
STREAM REACH     2.  RCHWALNUT               FROM        45.0    TO          39.0
STREAM REACH     3.  RCHFM149 FM2978         FROM        39.0    TO          34.0
STREAM REACH     4.  RCHFM2978 GOSLING       FROM        34.0    TO          24.5
STREAM REACH     5.  RCHGOSLING WILLOW       FROM        24.5    TO          20.5
STREAM REACH     6.  RCHWILLOW CREEK         FROM        10.0    TO            .0
STREAM REACH     7.  RCHWILLOW PANTHER       FROM        20.5    TO          17.5
STREAM REACH     8.  RCHPANTHER BRANCH       FROM        10.0    TO            .0
STREAM REACH     9.  RCHPANTHER IH45         FROM        17.5    TO          16.0
STREAM REACH    10.  RCHIH45 RILEY-FUSL      FROM        16.0    TO          13.0
STREAM REACH    11.  RCHBELOW RILEY-FUSL     FROM        13.0    TO           8.0
STREAM REACH    12.  RCHABOVE CYPRESS        FROM         8.0    TO           3.5
STREAM REACH    13.  RCHBELOW CYPRESS        FROM         3.5    TO            .0
ENDATA2          0.                                       .0                   .0
```

$$$ DATA TYPE 3 (TARGET LEVEL DO AND FLOW AUGMENTATION SOURCES) $$$

CARD TYPE	REACH	AVAIL HOWS	TARGET	ORDER OF AVAIL SOURCES					
FLOW AUGMT SOURCES	1.	0.	.0	0.	0.	0.	0.	0.	0.
FLOW AUGMT SOURCES	2.	0.	.0	0.	0.	0.	0.	0.	0.
FLOW AUGMT SOURCES	3.	0.	.0	0.	0.	0.	0.	0.	0.
FLOW AUGMT SOURCES	4.	0.	.0	0.	0.	0.	0.	0.	0.
FLOW AUGMT SOURCES	5.	0.	.0	0.	0.	0.	0.	0.	0.
FLOW AUGMT SOURCES	6.	0.	.0	0.	0.	0.	0.	0.	0.
FLOW AUGMT SOURCES	7.	0.	.0	0.	0.	0.	0.	0.	0.
FLOW AUGMT SOURCES	8.	0.	.0	0.	0.	0.	0.	0.	0.
FLOW AUGMT SOURCES	9.	0.	.0	0.	0.	0.	0.	0.	0.
FLOW AUGMT SOURCES	10.	0.	.0	0.	0.	0.	0.	0.	0.
FLOW AUGMT SOURCES	11.	0.	.0	0.	0.	0.	0.	0.	0.
FLOW AUGMT SOURCES	12.	0.	.0	0.	0.	0.	0.	0.	0.
FLOW AUGMT SOURCES	13.	0.	.0	0.	0.	0.	0.	0.	0.
ENDATA3	0.	0.	.0	0.	0.	0.	0.	0.	0.

$$$ DATA TYPE 4 (COMPUTATIONAL REACH FLAG FIELD) $$$

CARD TYPE	REACH	ELEMENTS/REACH	COMPUTATIONAL FLAGS
FLAG FIELD	1.	10.	1.2.2.2.6.2.2.2.2.2.**********
FLAG FIELD	2.	12.	2.2.2.2.6.2.2.2.2.2.6.2.**********
FLAG FIELD	3.	16.	2.2.2.2.2.2.6.2.6.2.**********
FLAG FIELD	4.	19.	2.2.2.2.2.6.2.2.2.2.2.2.2.2.2.2.6.2.**
FLAG FIELD	5.	8.	2.2.2.2.2.6.2.3.**********
FLAG FIELD	6.	20.	1.2.2.2.2.2.6.2.6.6.2.2.2.2.2.2.6.2.2.2.
FLAG FIELD	7.	6.	4.6.2.2.2.3.**********
FLAG FIELD	8.	20.	1.2.2.2.2.2.2.2.2.2.2.2.6.2.6.2.2.2.2.2.
FLAG FIELD	9.	3.	4.2.2.**********
FLAG FIELD	10.	6.	6.2.2.2.6.2.**********
FLAG FIELD	11.	10.	2.2.2.6.2.2.2.6.2.2.**********
FLAG FIELD	12.	9.	2.2.2.2.2.2.2.2.2.**********
FLAG FIELD	13.	7.	6.6.2.2.2.2.5.**********
ENDATA4	0.	0.	**********

$$$ DATA TYPE 5 (HYDRAULIC COEFFICIENTS FOR DETERMINING VELOCITY AND DEPTH) $$$

CARD TYPE	REACH	COEFUV	EXPOUV	COEFDH	EXPODH	CHANN
HYDRAULICS	1.	.0500000	.500	1.300	.500	.035
HYDRAULICS	2.	.0500000	.500	1.300	.500	.035
HYDRAULICS	3.	.0500000	.500	1.300	.500	.035
HYDRAULICS	4.	.0500000	.500	1.300	.500	.035
HYDRAULICS	5.	.0600000	.500	.800	.500	.035
HYDRAULICS	6.	.1000000	.500	1.100	.500	.035
HYDRAULICS	7.	.0600000	.500	.800	.500	.035
HYDRAULICS	8.	.1000000	.500	1.100	.500	.035
HYDRAULICS	9.	.0600000	.500	.800	.500	.035
HYDRAULICS	10.	.1000000	.500	.200	.500	.035
HYDRAULICS	11.	.1000000	.500	.150	.500	.035
HYDRAULICS	12.	.1000000	.500	.110	.500	.035
HYDRAULICS	13.	.1000000	.500	.080	.500	.035
ENDATA5	0.	.0000000	.000	.000	.000	.000

$$$ DATA TYPE 6 (REACTION COEFFICIENTS FOR DEOXYGENATION AND REAERATION) $$$

CARD TYPE	REACH	K1	K3	K2CPT	K2	COEFK2	EXPONK2
REACT COEF	1.	.00	.00	1.	.00	.000	.000
REACT COEF	2.	.00	.00	1.	.00	.000	.000
REACT COEF	3.	.10	.00	3.	.00	.000	.000
REACT COEF	4.	.10	.00	3.	.00	.000	.000
REACT COEF	5.	.10	.00	3.	.00	.000	.000
REACT COEF	6.	.10	.00	3.	.00	.000	.000
REACT COEF	7.	.10	.00	3.	.00	.000	.000
REACT COEF	8.	.10	.00	3.	.00	.000	.000
REACT COEF	9.	.10	.00	3.	.00	.000	.000
REACT COEF	10.	.10	.00	3.	.00	.000	.000
REACT COEF	11.	.10	.00	3.	.00	.000	.000
REACT COEF	12.	.20	.00	3.	.00	.000	.000
REACT COEF	13.	.20	.00	3.	.00	.000	.000
ENDATA6	0.	.00	.00	0.	.00	.000	.000

$$$ DATA TYPE 6A (ALGAE, NITROGEN, AND PHOSPHOROUS CONSTANTS) $$$

CARD TYPE	REACH	ALPHAD	ALGSET	CKNH3	CKNO2	SKNH3	SPON	ORG-N
ALGAE, N AND P COEF	1.	75.0	.00	.00	.00	.00	.00	.00
ALGAE, N AND P COEF	2.	75.0	.00	.00	.00	.00	.00	.00
ALGAE, N AND P COEF	3.	75.0	.00	.35	1.50	.00	.00	.04
ALGAE, N AND P COEF	4.	75.0	.00	.35	1.50	.00	.00	.04
ALGAE, N AND P COEF.	5.	75.0	.00	.35	1.50	.00	.00	.04
ALGAE, N AND P COEF	6.	75.0	.00	.35	1.50	.00	.00	.04
ALGAE, N AND P COEF	7.	75.0	.00	.35	1.50	.00	.00	.04
ALGAE, N AND P COEF	8.	75.0	.00	.35	1.50	.00	.00	.04
ALGAE, N AND P COEF	9.	75.0	.00	.35	1.50	.00	.00	.04
ALGAE, N AND P COEF	10.	75.0	.00	.40	1.50	.00	.00	.04
ALGAE, N AND P COEF	11.	75.0	.00	.40	1.50	.00	.00	.04
ALGAE, N AND P COEF	12.	75.0	.00	.40	1.50	.00	.00	.04
ALGAE, N AND P COEF	13.	75.0	.00	.40	1.50	.00	.00	.04
ENDATA6A	0.	.0	.00	.00	.00	.00	.00	.00

$$$ DATA TYPE 6E (OTHER COEFFICIENTS) $$$

CARD TYPE	REACH	CK4	CK5	FACDEF	CK6
OTHER COEFFICIENTS	1.	.00	.00	.10	.00
OTHER COEFFICIENTS	2.	.00	.00	.10	.00
OTHER COEFFICIENTS	3.	1500.00	.10	.10	.00
OTHER COEFFICIENTS	4.	1500.00	.10	.10	.00
OTHER COEFFICIENTS	5.	1000.00	.10	.10	.00
OTHER COEFFICIENTS	6.	500.00	.10	.10	.00
OTHER COEFFICIENTS	7.	1000.00	.10	.10	.00
OTHER COEFFICIENTS	8.	500.00	.10	.10	.00
OTHER COEFFICIENTS	9.	1000.00	.10	.10	.00
OTHER COEFFICIENTS	10.	1000.00	.10	.10	.00
OTHER COEFFICIENTS	11.	800.00	.10	.10	.00
OTHER COEFFICIENTS	12.	800.00	.10	.10	.00
OTHER COEFFICIENTS	13.	800.00	.10	.10	.00
ENDATAGR	0.	.00	.00	.00	.00

$$$ DATA TYPE 7 (INITIAL CONDITIONS) $$$

CARD TYPE	REACH	TEMP	D.O.	POP	CM-I	CM-II	CM-III
INITIAL CONDITIONS	1.	81.0	.0	.0	.0	.0	.0
INITIAL CONDITIONS	2.	81.0	.0	.0	.0	.0	.0
INITIAL CONDITIONS	3.	81.0	.0	.0	.0	.0	.0
INITIAL CONDITIONS	4.	81.0	.0	.0	.0	.0	.0
INITIAL CONDITIONS	5.	81.0	.0	.0	.0	.0	.0
INITIAL CONDITIONS	6.	81.0	.0	.0	.0	.0	.0
INITIAL CONDITIONS	7.	81.0	.0	.0	.0	.0	.0
INITIAL CONDITIONS	8.	81.0	.0	.0	.0	.0	.0
INITIAL CONDITIONS	9.	81.0	.0	.0	.0	.0	.0
INITIAL CONDITIONS	10.	81.0	.0	.0	.0	.0	.0
INITIAL CONDITIONS	11.	81.0	.0	.0	.0	.0	.0
INITIAL CONDITIONS	12.	81.0	.0	.0	.0	.0	.0
INITIAL CONDITIONS	13.	81.0	.0	.0	.0	.0	.0
ENDATAP	0.	.0	.0	.0	.0	.0	.0

$$$ DATA TYPE 7A (INITIAL CONDITIONS FOR CHLOROPHYLL A, NITROGEN, PHOSPHORUS, COLIFORM AND RADIONUCLIDE) $$$

CARD TYPE	REACH	CHLORA	NH3	NO_2	NO3	PO4	COLI	RADN	ORG-N
INITIAL COND-2	1.	.0	.00	.00	.00	.00	.0	.00	.00
INITIAL COND-2	2.	.0	.00	.00	.00	.00	.0	.00	.00
INITIAL COND-2	3.	.0	.00	.00	.00	.00	.0	.00	.00
INITIAL COND-2	4.	.0	.00	.00	.00	.00	.0	.00	.00
INITIAL COND-2	5.	.0	.00	.00	.00	.00	.0	.00	.00
INITIAL COND-2	6.	.0	.00	.00	.00	.00	.0	.00	.00
INITIAL COND-2	7.	.0	.00	.00	.00	.00	.0	.00	.00
INITIAL COND-2	8.	.0	.00	.00	.00	.00	.0	.00	.00
INITIAL COND-2	9.	.0	.00	.00	.00	.00	.0	.00	.00
INITIAL COND-2	10.	.0	.00	.00	.00	.00	.0	.00	.00
INITIAL COND-2	11.	.0	.00	.00	.00	.00	.0	.00	.00
INITIAL COND-2	12.	.0	.00	.00	.00	.00	.0	.00	.00
INITIAL COND-2	13.	.0	.00	.00	.00	.00	.0	.00	.00
ENDATAP	0.	.0	.00	.00	.00	.00	.0	.00	.00

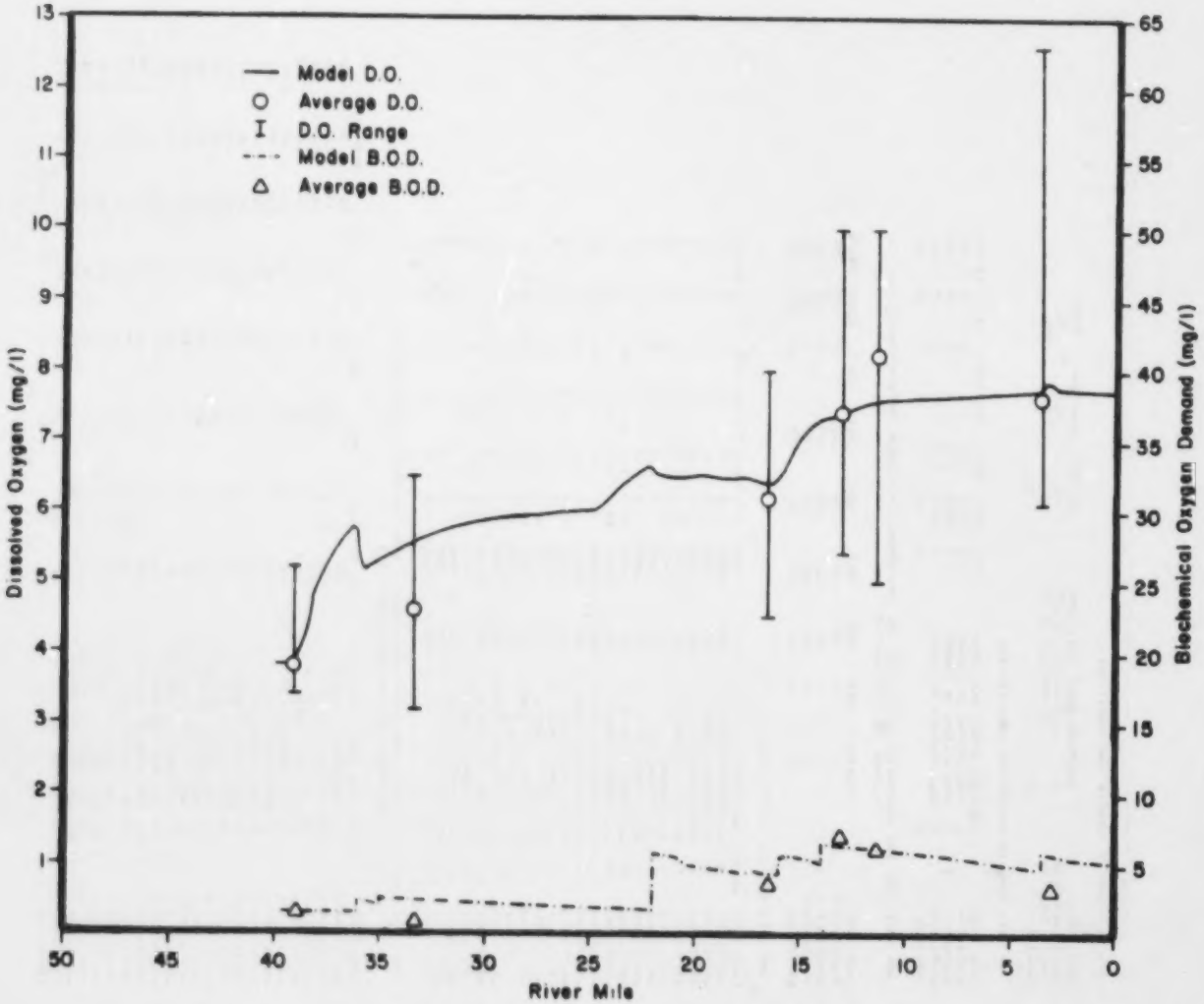
$$$ DATA TYPE 8 (RUNOFF CONDITIONS) $$$

CARD TYPE	REACH	L	TEMP	D.O.	POP	CM-I	CM-II	CM-III
RUNOFF CONDITIONS	1.	.0	81.0	0.0	0.0	.0	.0	.0
RUNOFF CONDITIONS	2.	.0	81.0	0.0	0.0	.0	.0	.0
RUNOFF CONDITIONS	3.	1.3	81.0	0.0	0.0	.0	.0	.0
RUNOFF CONDITIONS	4.	2.2	81.0	0.0	0.0	.0	.0	.0
RUNOFF CONDITIONS	5.	1.2	81.0	0.0	0.0	.0	.0	.0
RUNOFF CONDITIONS	6.	.0	81.0	0.0	0.0	.0	.0	.0
RUNOFF CONDITIONS	7.	.9	81.0	0.0	0.0	.0	.0	.0
RUNOFF CONDITIONS	8.	.0	81.0	0.0	0.0	.0	.0	.0
RUNOFF CONDITIONS	9.	.9	81.0	0.0	0.0	.0	.0	.0
RUNOFF CONDITIONS	10.	.9	81.0	0.0	0.0	.0	.0	.0
RUNOFF CONDITIONS	11.	1.0	81.0	0.0	0.0	.0	.0	.0
RUNOFF CONDITIONS	12.	.9	81.0	0.0	0.0	.0	.0	.0
RUNOFF CONDITIONS	13.	.7	81.0	0.0	0.0	.0	.0	.0
ENDATARA	0.	.0	.0	.0	.0	.0	.0	.0

$$$ DATA TYPE 8A (INCREMENTAL FLOW CONDITIONS FOR NITROGEN, PHOSPHORUS, COLIFORM AND RADIONUCLIDE) $$$

CARD TYPE	REACH	CHLORA	NH3	NO_2	NO3	PO4	COLI	RADN	ORG-N
RUNOFF COND-2	1.	.0	.00	.00	.00	.00	.0	.00	.00
RUNOFF COND-2	2.	.0	.00	.00	.00	.00	.0	.00	.00
RUNOFF COND-2	3.	.0	.00	.00	.00	.00	.0	.00	.00
RUNOFF COND-2	4.	.0	.00	.00	.00	.00	.0	.00	.00
RUNOFF COND-2	5.	.0	.00	.00	.00	.00	.0	.00	.00
RUNOFF COND-2	6.	.0	.00	.00	.00	.00	.0	.00	.00
RUNOFF COND-2	7.	.0	.00	.00	.00	.00	.0	.00	.00
RUNOFF COND-2	8.	.0	.00	.00	.00	.00	.0	.00	.00
RUNOFF COND-2	9.	.0	.00	.00	.00	.00	.0	.00	.00
RUNOFF COND-2	10.	.0	.00	.00	.00	.00	.0	.00	.00
RUNOFF COND-2	11.	.0	.00	.00	.00	.00	.0	.00	.00
RUNOFF COND-2	12.	.0	.00	.00	.00	.00	.0	.00	.00
RUNOFF COND-2	13.	.0	.00	.00	.00	.00	.0	.00	.00
ENDATARA	0.	.0	.00	.00	.00	.00	.0	.00	.00

```
$$$ DATA TYPE 9 (STREAM JUNCTIONS) $$$

CARD TYPE                JUNCTION ORDER AND IDENT          UPSTRM   JUNCTION    TRIB
STREAM JUNCTION          1.      JNC:WILLOW CR JCT          59.       80.       79.
STREAM JUNCTION          2.      JNC:PANTHER BR JCT         85.      106.      105.
ENDATA9                  0.                                  0.        0.        0.

$$$ DATA TYPE 10 (HEADWATER SOURCES) $$$

CARD TYPE                HDWATER ORDER AND IDENT      FLOW  TEMP  D.O.   BOD CN-I  CN-II CN-III
HEADWATER                1.  HWD:SPRING CR SOURCE     4.8  81.0   3.8   1.6    .0     .0     .0
HEADWATER                2.  HWD:WILLOW CR SOURCE     1.5  80.0   6.0   1.0    .0     .0     .0
HEADWATER                3.  HWD:PANTHER BR SOURC      .1  80.0   6.0   1.0    .0     .0     .0
ENDATA10                 0.                            .0    .0    .0    .0    .0     .0     .0

$$$ DATA TYPE 10A (HEADWATER CONDITIONS FOR CHLOROPHYLL,NITROGEN, PHOSPHOROUS,
                  COLIFORM AND RADIONUCLIDE) $$$

CARD TYPE                HDWATER CHLORA   NH3    NO2    NO3    PO4    COLI   RADN  ORG-N
HEADWATER-2              1.       .0    .00    .02    .30    .32     .0    .00    .80
HEADWATER-2              2.       .0    .00    .02    .30    .00     .0    .00   1.00
HEADWATER-2              3.       .0    .00    .02    .30    .00     .0    .00   1.00
ENDATA10A                0.       .0    .00    .00    .00    .00     .0    .00    .00

$$$ DATA TYPE 11 (WASTE LOADINGS) $$$

CARD TYPE  WASTE LOAD ORDER AND IDENT  EFF      FLOW  TEMP  D.O.   BOD CN-I  CN-II CN-III
WASTELOAD     1.  WSL:BRUSHY CREEK     .00     .0000    .0    .0    .0    .0     .0     .0
WASTELOAD     2.  WSL:WALNUT CREEK     .00     .0000    .0    .0    .0    .0     .0     .0
WASTELOAD     3.  WSL:FUTURE #3        .00     .0000    .0    .0    .0    .0     .0     .0
WASTELOAD     4.  WSL:MILL CREEK       .00    4.0000   81.0   4.0   1.0    .0     .0     .0
WASTELOAD     5.  WSL:TOMBALL STP      .00     .3420   91.0   3.4  13.5    .0     .0     .0
WASTELOAD     6.  WSL:FUTURE #6        .00     .0000    .0    .0    .0    .0     .0     .0
WASTELOAD     7.  WSL:FUTURE #7        .00     .0000    .0    .0    .0    .0     .0     .0
WASTELOAD     8.  WSL:MONT CO WCID 1   .00     .3940   81.0   3.1 144.0    .0     .0     .0
WASTELOAD     9.  WSL:DOWDELL MUD      .00     .0940   82.0   3.0   4.5    .0     .0     .0
WASTELOAD    10.  WSL:HARRIS CO MUD 1  .00     .0000    .0    .0    .0    .0     .0     .0
WASTELOAD    11.  WSL:HARRIS CO MUD 35 .00     .0000    .0    .0    .0    .0     .0     .0
WASTELOAD    12.  WSL:HC NORCHESTR MUD .00     .3090   81.0   3.0   3.0    .0     .0     .0
WASTELOAD    13.  WSL:FWCANTO REAL RD  .00     .0000    .0    .0    .0    .0     .0     .0
WASTELOAD    14.  WSL:MONT CO MUD 6    .00     .1930   82.0   3.0   6.0    .0     .0     .0
WASTELOAD    15.  WSL:WOODLWD DRAINAGE .00    2.0000   82.0   4.0   7.5    .0     .0     .0
WASTELOAD    16.  WSL:SD MONT MUD      .00    1.5230   82.0   5.3  25.5    .0     .0     .0
WASTELOAD    17.  WSL:SCUD SJWA FOXRUN .00     .1040   82.0    .0 227.0    .0     .0     .0
WASTELOAD    18.  WSL:HAR CO WCID #2   .00     .3170   82.0   6.1   5.0    .0     .0     .0
WASTELOAD    19.  WSL:GWCDA HC MUD #2  .00     .0340   81.0   5.2   6.0    .0     .0     .0
WASTELOAD    20.  WSL:CYPRESS CREEK    .00   10.9000   82.0   9.0   8.1    .0     .0     .0
WASTELOAD    21.  WSL:MUD 26 & 27      .00     .6000    .0    .0    .0    .0     .0     .0
ENDATA11      0.                       .00     .0000    .0    .0    .0    .0     .0     .0

$$$ DATA TYPE 11A (WASTE LOAD CHARACTERISTICS - ALGAE,NITROGEN,PHOSPHOROUS,
                  COLIFORMS AND RADIONUCLIDES) $$$

CARD TYPE  WASTE LOAD ORDER AND IDENT  CHL. A    NH3    NO2    NO3    PO4    COLI   RADN  ORG-N
WASTELOAD-2    1. WSL:BRUSHY CREEK      .00     .00    .00    .00    .00    .00    .00    .00
WASTELOAD-2    2. WSL:WALNUT CREEK      .00     .00    .00    .00    .00    .00    .00    .00
WASTELOAD-2    3. WSL:FUTURE #3         .00     .00    .00    .00    .00    .00    .00    .00
WASTELOAD-2    4. WSL:MILL CREEK        .00     .00    .07    .30    .00    .00    .00    .00
WASTELOAD-2    5. WSL:TOMBALL STP       .00     .00    .05   18.05   5.70   .00    .00   1.40
WASTELOAD-2    6. WSL:FUTURE #6         .00     .00    .00    .00    .00    .00    .00    .00
WASTELOAD-2    7. WSL:FUTURE #7         .00     .00    .00    .00    .00    .00    .00    .00
WASTELOAD-2    8. WSL:MONT CO WCID 1    .00   13.50    .56    .23   4.60    .00    .00   4.30
WASTELOAD-2    9. WSL:DOWDELL MUD       .00    8.00    .10  10.00   4.00    .00    .00   9.00
WASTELOAD-2   10. WSL:HARRIS CO MUD 1   .00     .00    .00    .00    .00    .00    .00    .00
WASTELOAD-2   11. WSL:HARRIS CO MUD 35  .00     .00    .00    .00    .00    .00    .00    .00
WASTELOAD-2   12. WSL:HC NORCHESTR MUD  .00     .00    .25   6.50   7.60    .00    .00   1.30
WASTELOAD-2   13. WSL:FWCANTO REAL RD   .00     .00    .00    .00    .00    .00    .00    .00
WASTELOAD-2   14. WSL:MONT CO MUD 6     .00    8.00    .10  10.00   4.00    .00    .00   9.00
WASTELOAD-2   15. WSL:WOODLWD DRAINAGE  .00    1.00    .10  10.00    .00    .00    .00   2.00
WASTELOAD-2   16. WSL:SD MONT MUD       .00   16.30    .06    .09   4.70    .00    .00   4.10
WASTELOAD-2   17. WSL:SCUD SJWA FOXRUN  .00   25.00    .00    .00  10.40    .00    .00   6.70
WASTELOAD-2   18. WSL:HAR CO WCID #2    .00     .00    .05  14.70   6.00    .00    .00   1.30
WASTELOAD-2   19. WSL:GWCDA HC MUD #2   .00    5.40    .65   5.05   7.70    .00    .00   2.30
WASTELOAD-2   20. WSL:CYPRESS CREEK     .00     .00    .54   2.93   2.60    .00    .00   1.50
WASTELOAD-2   21. WSL:MUD 26 & 27       .00     .00    .00    .00    .00    .00    .00    .00
ENDATA11A                              .00     .00    .00    .00    .00   .000
```



ATTACHMENT K: CALIBRATION — AUG. 4, 1976 SURVEY
RESPONSE CURVES
FOR SPRING CREEK MODEL

ATTACHMENT L

WASTEWATER TREATMENT PLANT DISCHARGE DESCRIPTION

Alternative Number: _____

Plant Name: _____

Waste Control Order Number: _____

Segment Name & Number: _____

Location:

Comments:

	Existing Discharge (12 Mos. Avg.)	Existing W.C.O. Limits	Proposed Discharge
Q (MGD)			
a) 30 day average	_____	_____	_____
b) 7 day average	_____	_____	_____
BOD_5 (mg/l)			
a) 30 day average	_____	_____	_____
b) 7 day average	_____	_____	_____
NH_3-N (mg/l)			
a) 30 day average	_____	_____	_____
b) 7 day average	_____	_____	_____
Fecal Coliform (#/100 ml.)	_____	_____	_____
Effluent D.O. (mg/l)	_____	_____	_____
Effluent Temp. (^{o}C)	_____	_____	_____
Chlorine Residual (mg/l)	_____	_____	_____

WATER QUALITY MODELING
FOR THE
208 DESIGNATED PLANNING AREAS

HOUSTON AREA STEADY-STATE MODELING REPORTS

CYPRESS CREEK - SEGMENT 1009

Prepared by:

Administrative Operations Division
Texas Water Quality Board
Austin, Texas

for the

Houston-Galveston Area Council

and the

U. S. Environmental Protection Agency

The preparation of this report was financed through planning grants from the U. S. Environmental Protection Agency through the Houston-Galveston Area Council.

May, 1977

TABLE OF CONTENTS

		PAGE
I.	INTRODUCTION	1
II.	DESCRIPTION OF STUDY AREA	1
III.	PRESENTATION OF DATA	2
	A) Historical Quality Problem	2
	B) Existing Water Quality	3
	C) Present Waste Loadings	4
	D) Hydrological Data	4
IV.	MATHEMATICAL MODEL FORMULATION	4
V.	MATHEMATICAL MODELING OF WATER QUALITY	5
	A) General	6
	B) Segmentation	6
	C) Hydraulics	7
	D) Atmospheric Reaeration	7
	E) Carbonaceous Demands	8
	F) Nitrogenous Demands	8
	G) Benthal Demands	9
	H) Photosynthesis/Respiration	9
	I) Coliforms	9
	J) Temperature Correction Factors	10
VI.	MODEL ANALYSIS	10
VII.	SENSITIVITY ANALYSIS	11
VIII.	RECOMMENDATIONS FOR MODEL USE	12
IX.	SUMMARY	14

LIST OF ATTACHMENTS

		PAGE
A	HOUSTON AREA - Segment Location Map	A-1
B-1	CYPRESS CREEK - Segment 1009	B-1
B-2	CYPRESS CREEK - Segment 1009	B-2
B-3	MAP LEGEND - Cypress Creek	B-3
C	TWQB STREAM MONITORING DATA - Cypress Creek	C-1
D	USGS STREAM MONITORING DATA - Cypress Creek	D-1
E-1	CYPRESS CREEK DIURNAL FIELD MEASUREMENTS February 11, 1976 City of Houston Survey	E-1
E-2	CYPRESS CREEK LABORATORY ANALYSES February 11, 1976 City of Houston Survey	E-2
E-3	CYPRESS CREEK DIURNAL COLIFORM ANALYSES February 11, 1976 City of Houston Survey	E-3
F	EXISTING WASTE LOADS ON CYPRESS CREEK	F-1
G	CYPRESS CREEK WASTE LOADS - February 11, 1976	G-1
H	CYPRESS CREEK HYDRAULIC MEASUREMENTS	H-1
J-1	CYPRESS CREEK SCHEMATIC	J-1
J-2	SCHEMATIC EXPLANATION	J-2
K	CYPRESS CREEK - QUAL-II Model Input	K-1
L	CALIBRATION - Response Curves for Cypress Creek Model - February 11, 1976	L-1
M	WASTEWATER TREATMENT PLANT DISCHARGE DESCRIPTION . .	M-1

I. INTRODUCTION

This report has been prepared in accordance with an agreement between the Texas Water Quality Board and the Houston-Galveston Area Council covering the improvement of steady-state mathematical models of stream water quality for the Houston "208" Area. As required in TASK 2.63, the purpose of the report is to incorporate data obtained through TASK 2.62 into an existing steady-state stream model to improve the model's predictive capability of water quality along Cypress Creek (Segment 1009). The model used is a generalized steady-state model, QUAL-II, prepared for the Environmental Protection Agency by Water Resources Engineers, Inc., in May, 1973.

A general description of the study area along with past and present water quality conditions are discussed. The major waste dischargers are summarized. The choice of model and the significant physical and chemical parameters needed as input into the model are presented. The results of the model calibration/verification attempts are presented and discussed. An analysis to determine the sensitivity of the model parameters is included. A final section discusses the actual use of the model.

II. DESCRIPTION OF STUDY AREA

The study area consists of Cypress Creek from its headwaters in eastern Waller County to its confluence with Spring Creek (Segment 1008) some 6 miles upstream of Lake Houston (see Attachment A). Cypress Creek originates a few miles south of the City of Waller where it is formed by the junction of Snake Creek and Mound Creek. From there, it flows southeastward for a few miles along the Waller-Harris County boundary. It then crosses into Harris County where it flows eastward to its confluence with Spring Creek. The total length of the stream is 55 miles, and the drainage area is approximately 322 square miles. Principal tributaries include Little Cypress Creek which drains an area of about 53 square miles and Mound and Snake Creeks which together drain an area of about 53 square miles.

The majority of the segment has historically been rural. Above U. S. Highway 290, the watershed consists largely of prairie land used for rice production and pasture. Below U. S. 290, the watershed is heavily wooded providing very desirable sites for residential development. This portion is currently in the midst of a rapidly growing suburban-residential

development resulting from the continuing expansion of the Houston Metropolitan Area from the south. As a result of the rapid growth, numerous sewage treatment plants have been built along Cypress Creek and its tributaries. Thirty-one plants presently discharge along Cypress Creek with twenty-nine of them lying in the 20-mile reach between U. S. 290 on the west and Aldine-Westfield Road on the east. The upper portion of the stream above U. S. 290 is located in a sparsely settled area and the land use can be classified as rural and low density residential. The only wastewater treatment plant in this area belongs to the City of Waller and discharges into Mound Creek.

III. PRESENTATION OF DATA

A) Historical Quality Problem

The Texas Water Quality Board maintains four water quality monitoring stations on Cypress Creek (see Attachment B) at Aldine-Westfield Road (Station No. 1009.005), I. H. 45 (Station No. 1009.01), Kuykendahl Road (Station No. 1009.02), and Steubner-Airline Road (Station No. 1009.03). The United States Geological Survey maintains two water quality monitoring stations on Cypress Creek at Tettar Road (Station No. 8069200) and U. S. 290 (Station No. 8068750). Dissolved oxygen and fecal coliform standards for Segment 1009 are 5.0 mg/l and 2,000/100 ml, respectively. Water quality data gathered at these stations from October 1971 to December 1976 are shown in Attachments C and D and indicate that the segment has had problems with low dissolved oxygen levels and high fecal coliform counts.

Since 1971, four violations of the dissolved oxygen standard have occurred at I. H. 45. The dissolved oxygen concentration was 3.8 mg/l in July 1972 (streamflow = 42 cfs, stream temperature = 78°F), 4.0 mg/l in October 1972 (9.6 cfs, 84°F), 4.6 mg/l in October 1973 (2,830 cfs, 66°F), and 4.9 mg/l in June 1974 (8 cfs, 80°F). At U. S. 290, the dissolved oxygen dropped to 4.4 mg/l in August 1972. Explanations for the dissolved oxygen violations include variations due to phytoplankton respiration and photosynthesis, flow variations from sewage treatment plants, plant upsets, sludge deposits, localized low stream velocities, and stormwater runoff.

The fecal coliform standard at I. H. 45 was exceeded in two out of three samples in 1972, four out of four samples in 1973, one out of four samples in 1975, and one out of two samples in 1976. At Aldine-Westfield Road, the standard was exceeded in five out of eight samples in 1976. At Kuykendahl Road, the standard was exceeded in three out of eight samples in 1976. The fecal coliform data obtained at these stations were not collected at a frequency adequate to determine compliance with the logarithmic mean criterion.

B) Existing Water Quality

The City of Houston conducted a water quality survey on Cypress Creek February 11, 1976 in conjunction with the "208" modeling effort. These surveys were originally designed to provide data for model calibration and verification. Stream sampling stations were located at Tettar Road, Aldine-Westfield Road, I. H. 45, Steubner-Airline Road, FM 149, and U. S. 290 as shown in Attachment B.

Field measurements were taken approximately once every three hours for twenty-four hours. The field parameters measured include dissolved oxygen, temperature, pH, and conductivity. Composite samples over the twenty-four hour period were also taken at each station for laboratory analysis. The parameters measured in the laboratory include biochemical oxygen demand, organic nitrogen, ammonia nitrogen, nitrite nitrogen, nitrate nitrogen, total phosphorus, chlorophyll a, total suspended solids, and total dissolved solids. Total coliform and fecal coliform were also determined. A summary of the diurnal field measurements and the laboratory analyses are contained in Attachment E.

After the February survey, analysis of Cypress Creek and Spring Creek indicated that unexpectedly low BOD values in the streams may have been caused by toxicity in the BOD test. Indications were that treatment plant operators may have increased chlorine feed rates during the surveys thus resulting in high instream chlorine residuals. For the second Spring Creek survey in August, chlorine residuals were measured and split samples were sent to the EPA lab in Houston to check laboratory procedures. Analysis of the Spring Creek survey confirmed the previously suspected high chlorine residuals. The Cypress Creek results probably reflect the same stream conditions. As a result, the BOD values reported should be viewed carefully. The actual values may be higher than the observed BOD values.

Further analysis of the data indicates that during the February 11, 1976 survey, the average dissolved oxygen violated the standard at four of the six stations. The dissolved oxygen concentration was 4.7 mg/l at U. S. 290 (streamflow = 0.48 cfs, stream temperature = 70°F), 4.3 mg/l at FM 149 (0.48 cfs, 69°F), 4.1 mg/l at Steubner-Airline Road (2.24 cfs, 68°F), and 4.5 mg/l at Tettar Road (65°F). As the data shows, Cypress Creek is presently experiencing water quality problems based on TWQB water quality standards.

C) Present Waste Loadings

The average waste loadings during the period of January 1976 to September 1976 for dischargers along Cypress Creek are presented in Attachment F. Attachment G summarizes the waste loadings during the February 11, 1976 survey. The waste loadings are based on the February 11, 1976 survey, TWQB self-reporting data, and TWQB return flow data.

D) Hydrological Data

The United States Geological Survey maintains four continuous streamflow monitoring stations on Cypress Creek at Sharp Road (Station No. 8068700), Katy-Hockley Road (Station No. 8068720), House-Hahl Road (Station No. 8068740) and at I. H. 45 (Station No. 8069000). In addition to the average daily flows obtained at these stations, instantaneous flows were obtained during the February 11, 1976 dye study. The flows from the USGS stations and the dye studies are presented in Attachment H along with velocities determined in the dye study. The 7 day - 2 year low flow for Cypress Creek is 0.19 cfs at I. H. 45.

IV. MATHEMATICAL MODEL FORMULATION

The steady-state model used for Cypress Creek is QUAL-II, an expanded version of QUAL-I. The QUAL-II model was chosen because of its ability to rapidly predict water quality profiles in an advective system and because it is well-known and widely used in the field of modeling.

QUAL-II uses a set of interrelated differential mass transport equations to describe the effects of advection, dispersion, decay, sources, and sinks for all water quality constituents being modeled. The transport equations are then solved by

numerical integration using an implicit-finite-difference technique under the assumption that advection along the primary axis of flow (longitudinal axis of the stream channel) is the primary model of transport. QUAL-II is capable of simulating carbonaceous biochemical oxygen demand (BOD), nitrogenous BOD through the nitrogen cycle, benthic oxygen demand, dissolved oxygen (DO), the nutrient cycles, algae production, coliforms, and conservative materials.

A schematic diagram of the model structure is presented in Attachment J. River reaches, which are aggregates of computation elements of equal length, are defined for stretches of the stream with uniform hydraulic and reaction characteristics. Hydraulic coefficients and exponents, reaction rate coefficients, initial conditions, and incremental runoff are assumed to be constant for all computational elements within a reach. Each computational element is considered completely-mixed and therefore has uniform water characteristics throughout with the average concentration represented as to point value in the center of each element.

Advantages

1) QUAL-II models the nitrogen cycle from organic nitrogen to ammonia to nitrite to nitrate.

2) Benthal oxygen demand and coliforms are included in the model.

3) QUAL-II is capable of modeling the algae-nutrient interactions.

4) QUAL-II is capable of handling tributaries.

5) The implicit solution technique is unconditionally stable.

6) The output is easy to read and analyze. An excellent plotting routine helps in visualizing the effects of waste loads.

7) The documentation that supports the model is good and simplifies the job of programming of the model.

Disadvantages

1) Only longitudinal variations in water properties are possible.

2) Uniform properties and instant mixing are assumed for each computational element.

3) Reaches must have constant properties along them.

4) Only steady-state hydraulics are capable of being modeled. Therefore, QUAL-II does not lend itself to unsteady-state modeling.

5) Although QUAL-II includes algae-nutrient interactions, the approach is somewhat simplified.

V. MATHEMATICAL MODELING OF WATER QUALITY

A) General

Dissolved oxygen modeling in both advective and estuarine systems is basically an attempt to keep an account of the major sources and sinks of oxygen in a system composed of a number of complex interacting subsystems (reaches), each with its own set of physical characteristics. The primary sources of oxygen are: 1) dissolved oxygen in tributary inflow waters, and 2) atmospheric reaeration. In some cases, the action of algae will, through photosynthesis, add oxygen to water. The primary sinks for oxygen are: 1) carbonaceous demands, 2) nitrogenous demands, 3) benthic demands, and 4) biological respiration.

Hydrodynamic factors fix the transport of oxygen and oxygen-demanding materials in and out of each element in the reach. In a river or stream, this is accomplished by advection. In an estuary, these factors consist of dispersive and advective components, freshwater flow and circulation. These parameters are significantly affected by the geometry and shape of each reach in the system.

B) Segmentation

One of the first steps in stream modeling is to divide the stream into reaches of constant characteristics. New segments or reaches may be established due to changes in cross-sectional areas, depth, width or velocity. Additional flow from tributaries or wastewater discharges may require that a new segment be established. A spatial variation from benthal demand or photosynthesis and respiration parameters may require additional segmentation.

The Cypress Creek model was segmented into eight reaches. The boundaries of the reaches occurred at points where sampling stations were located. The stream was considered to have constant characteristics between each station.

C) Hydraulics

After a stream has been segmented, it is necessary to specify the hydraulic and physical characteristics of each segment on the stream systems. Two equations are generally used to describe the hydraulic characteristics. The equations represent the relationship between discharge and velocity and discharge and depth. These relationships can be represented by exponential equations as shown below:

$$V = aQ^b$$

$$D = cQ^d$$

where:

V = mean velocity in a reach

Q = mean discharge in a reach

D = mean depth

a, b
c, d = coefficients

The velocity equation was formulated using data gathered by Farner & Winslow, Inc., during the February 1976 time-of-travel study on Cypress Creek (see attachment H). The depth equation was formulated from flow, velocity, and width measurements along Cypress Creek.

D) Atmospheric Reaeration

The reaeration process is generally a function of temperature, stream geometry, and stream hydraulics. Several techniques and equations have been developed to estimate reaeration coefficients based on stream geometry and stream characteristics. The equations are generally in the form given by Streeter & Phelps (1925):

$$K_2 = \frac{c\ \bar{u}^n}{D^2}$$

where:

$\bar{u}$ = mean stream velocity

D = mean stream depth

c, n = constants for a particular stream

In the Cypress Creek QUAL-II model, the O'Connor-Dobbins reaeration equation was used:

$$K_2\ (20°C) = \frac{12.84\ \bar{u}^{.5}}{D^{1.5}}$$

E) Carbonaceous Demands

Wastewater discharges from various types of treatment plants generally contain organic materials which will decompose in the presence of oxygen and certain bacteria. The bacteria which degrade the carbonaceous component of these organic materials are present in most waters and they begin the process of decomposition quickly. Carbonaceous oxygen demand is usually determined in the five-day biochemical oxygen demand test (BOD_5). In this test, the amount of oxygen consumed under aerobic conditions, at 20°C, is measured. It is frequently assumed that the ultimate carbonaceous demand is equal to 1.5 times the five-day oxygen demand. The BOD values input into the Cypress Creek model are ultimate BOD values determined by multiplying the BOD_5 by 1.5.

Carbonaceous decay rates are usually determined from plotting the stream BOD values downstream of a discharger against the time-of-travel down the stream. The slope of the line is the decay rate. This method proved unacceptable for Cypress Creek due to the large number of discharges which prevented isolating one BOD profile. The decay rates were adjusted so that the predicted BOD profiles matched the observed BOD profiles.

F) Nitrogenous Demands

Various nitrogen compounds exert an oxygen demand as they change from one form to another. These changes in form require the presence of a specific bacterial population. This population is not always available in sufficient

numbers to cause these changes, and under these circumstances, a delay or lag time is sometimes observed in the exertion of nitrogenous oxygen demand. The conversion of organic nitrogen to ammonia nitrogen is assumed to take place by hydrolysis and therefore exerts no oxygen demand. The conversion of ammonia nitrogen to nitrite nitrogen exerts an oxygen demand of 3.43 mg oxygen/mg nitrogen. The conversion of nitrite nitrogen to nitrate nitrogen exerts an oxygen demand of 1.14 mg oxygen/mg nitrogen.

The three nitrogenous decay rates were obtained from literature values. These rates were then adjusted to provide a reasonable fit between the predicted values and the observed values.

G) Benthal Demands

Bottom deposits, generally in the form of sludges discharged from municipal or industrial wastewater treatment plants, can exert an oxygen demand. These sludges accumulate below wastewater outfalls when stream velocities are not sufficient to keep solid particles in suspension. These sludges can exert an oxygen demand of from 5.0 to 1,000 milligrams of oxygen per square foot of bottom area per day. At higher treatment levels, the benthal demand will be reduced due to the reduction in discharged solids.

H) Photosynthesis/Respiration

The presence of algae can also have an effect on dissolved oxygen in surface waters. During periods of daylight, oxygen is produced as a by-product of photosynthesis. Oxygen is consumed during respiration. This complex system, involving both a source and sink of oxygen, frequently results in a diurnal variation in dissolved oxygen concentrations. The photosynthesis/respiration system can result in either a surplus or deficit of oxygen depending on a number of conditions including light intensities, available nutrients, and turbidity. The presence of algae is determined from chlorophyll a concentrations. No chlorophyll a was found during the February 1976 Cypress Creek survey.

I) Coliforms

Because of the previously noted high chlorine residuals, the coliform data collected on Cypress Creek proved

unacceptable for coliform calibration. Therefore, a literature value of 0.1 days^{-1} was chosen as the die-off rate.

J) Temperature Correction Factors

Many of the reactions which determine water quality in natural systems are dependent on temperature. This dependence is usually considered by changing the various rate constants according to the following equation:

$$K_T = K_{20}\ \theta^{(T-20)}$$

where K_T and K_{20} are rate constants at a temperature, T, and a 20° Centigrade, and θ is a temperature correction factor which depends on the reaction being considered. The following temperature correction factors are used:

Reaction	θ, Temperature Correction Factor
Atmospheric Reaeration	1.0159
Carbonaceous Decay	1.047
Nitrogenous Decay	1.047
Benthal Demand	1.065
Coliform Die-off	1.047

QUAL-II corrects all of above except benthal demand for temperature. The benthal demand must be corrected for temperature by hand before being input to the model.

VI. MODEL ANALYSIS

A calibration of the QUAL-II model for Cypress Creek was made using data gathered by the City of Houston and TWQB self-reporting data. The input data is given in Attachment K. The calibration is shown in Attachment L. Good agreement is shown between the calculated and the observed values for dissolved oxygen and biochemical oxygen demand. Minor differences between calculated and observed values may be attributed to numerous causes including but not limited to: a possible lack of steady-state conditions during the survey, unaccounted

nonpoint sources of pollution, the previously mentioned chlorine toxicity and inhibition, the possible presence of algae, and sampling and measurement errors. Given the reasonably good agreement shown in the calibration, the QUAL-II computer simulation model for Cypress Creek, discussed in this report, can be used to evaluate a variety of alternative treatment schemes for Cypress Creek.

VII. SENSITIVITY ANALYSIS

The output of any water quality simulation model depends on the hydraulics, rates, and waste loads which are input to the model. A list of the input values is given in Attachment K. It is useful to determine the sensitivity of this output to changes in input values. In the following sensitivity analysis, all but one parameter are held constant, and the remaining parameter value is varied by ± 20% about the value used in the calibrated model. The selection of a 20% variation is purely arbitrary. The following table lists changes in the dissolved oxygen at a critical point in the dissolved oxygen profile. The point chosen is at river mile 18 of the Cypress Creek and has a value of 4.35 mg/l in the calibrated model. The table shows only relative sensitivity of model output to changes in the input values.

Sensitivity of Model Output to Changes in Input Parameters. Dissolved Oxygen Concentrations at River Mile 24

Parameter	-20%*	+20%*	Difference
Stream Depth	5.38	3.34	2.04
Benthal Demand	4.71	3.99	0.72
Temperature	4.02	4.71	0.69
Effluent NH_3	4.12	4.60	0.48
KNH3, NH_3 Decay Rate	4.58	4.14	0.44
Effluent Flow	4.54	4.19	0.35

Parameter	-20%*	+20%*	Difference
Effluent BOD	4.40	4.29	0.11
K1, BOD Decay Rate	4.30	4.40	0.10
Stream Velocity	4.37	4.31	0.06
Headwater Flow	4.34	4.35	0.01

*For temperature, ± 4°F

The table indicates that depth and benthal demand have the greatest relative effect on the calibrated model.

VIII. RECOMMENDATIONS FOR MODEL USE

It should be understood that the model calibration described in this report describes only a single set of conditions which existed in Cypress Creek during a particular set of conditions (flow, waste loads, temperature, etc.). Very careful consideration must be given to any changes in the listed input conditions. A change in one parameter might easily necessitate some change in a related rate or coefficient. For this reason, any alternate treatment scheme which is sent to the Texas Water Quality Board for evaluation of receiving water quality impact must be adequately described. Attachment M at the end of this report should be used to describe these alternate treatment schemes.

Some general comments can be made concerning the alternative runs without knowing the specifics of each alternative treatment scheme. The following recommendations are meant only as a general statement of parameter changes.

Hydraulics - The coefficients and exponents will be considered acceptable for low flow conditions in the range of those used in calibrating this model. If large changes in flow conditions occur, changes in the coefficients and exponents may be necessary.

Coefficients - During calibration, the coefficients for Reaches #1, #2 and #3 were set to zero since no data was available to calibrate them. If alternative runs concerning these reaches are necessary, the coefficients for these reaches will be set equal to those in Reach #4 and

the K_2 Option (K2OPT) set equal to 3. Otherwise, the beginning of Reach #4 will be considered as the headwater.

Because of the chlorine toxicity problems encountered during the surveys, there may be some justification in raising the CBOD decay rate (K1) and possibly the ammonia decay rate (CKNH3). However, any changes to these rates will have to be examined very carefully before adopting them.

The benthal rates are width and temperature dependent. Since no changes will be made in the hydraulic characteristics, the stream width will remain constant, and benthal rates need not be corrected for width. Unfortunately, at this time, the model does not correct benthal demands for temperature. When changing temperatures, the benthal demands must be changed using the following temperature correction:

$$B_T = B_{20}\ \theta^{T-20}$$

where:

B_T = Benthal rate at Temperature T

B_{20} = Benthal rate at 20°C

θ = Temperature correction factor (use 1.065)

T = Temperature (°C)

The following are the 20°C benthal rates:

Reach	Rate
4	760
5	1965
6	490
7	2485
8	1585

Because of the high chlorine residuals found in the streams, coliform calibration was impossible. An assumed coliform decay rate of 0.1 is to be used in the model. If evidence suggests using some other rate, we will consider changing it.

Initial Conditions - Only the steady-state temperature need be specified. It will be input according to conditions being modeled.

Runoff Conditions - Runoff conditions will be input according to conditions being modeled.

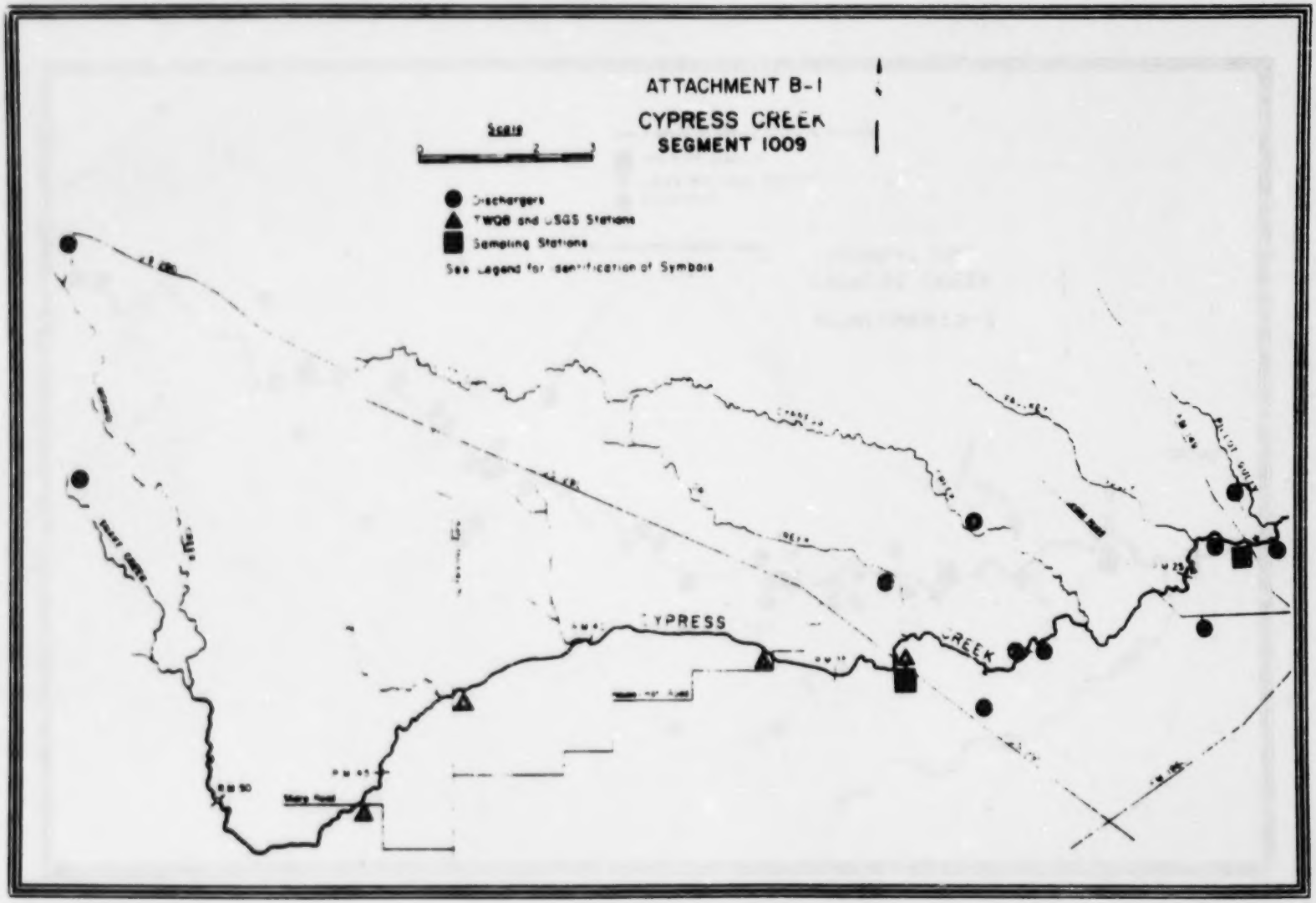
Headwater - Headwater conditions will be input according to conditions being modeled.

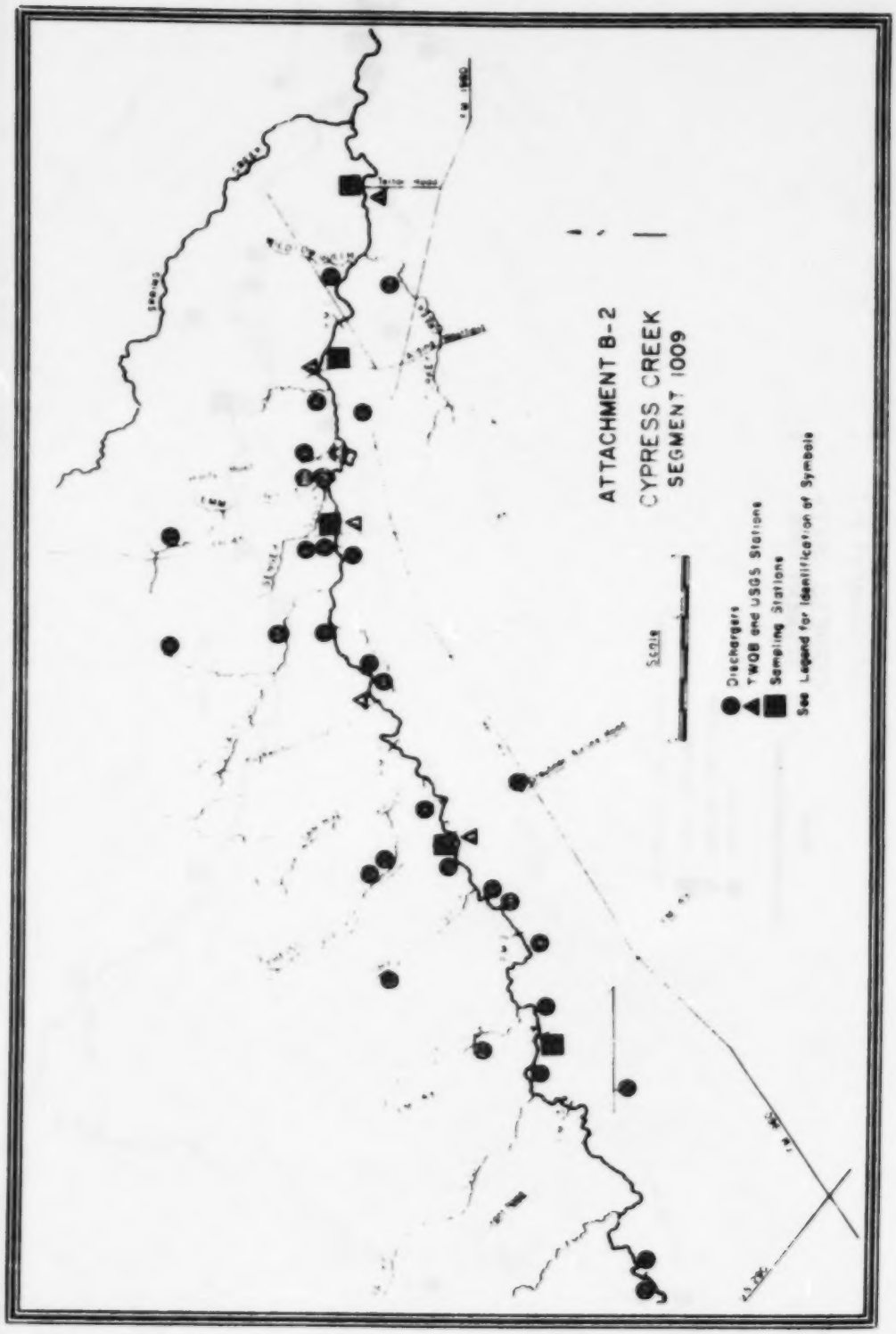
Waste Loads - Wasteloads will be input according to the alternative being modeled. BOD is ultimate BOD (1.5 x BOD_5). Organic nitrogen, ammonia, nitrite, and nitrate are entered as nitrogen (no oxygen equivalent factors necessary).

IX. SUMMARY

The staff of the Texas Water Quality Board has reviewed the data gathered in Cypress Creek by the City of Houston. Using this data and monitoring data from the Texas Water Quality Board, a one-dimensional steady-state computer model has been calibrated for use by the Texas Water Quality Board and related planning agencies.

ATTACHMENTS


ATTACHMENT B-1
CYPRESS CREEK
SEGMENT 1009
Scale
0 1 2 3
Dischargers
TWQB and USGS Stations
Sampling Stations
See Legend for Identification of Symbols
CYPRESS
CREEK


ATTACHMENT B-2
CYPRESS CREEK
SEGMENT 1009
Scale
Dischargers
TWQB and USGS Stations
Sampling Stations
See Legend for Identification of Symbols

ATTACHMENT B-3

MAP LEGEND

CYPRESS CREEK

Dischargers ●

A Trunkline Gas Company (WCO #00960.01)

B Cypress Fairbanks ISD (WCO #10867.01)

C Harris Co. WCID #110 (WCO #10792.01)

D WCID #116 (WCO #10955.01)

E Memorial Hills UD (WCO #11044.01)

F Stonegate #5 (WCO #11058.01)

H Ponderosa Central (WCO #11081.01)

J Lake Forest (WCO #11084.01)

K Tomball Road UD (WCO #11089.01)

L Bammel Central (WCO #11105.01)

M Haude Elementary (WCO #11129.01)

N Treschwig (WCO #11141.01)

P Timberlane (WCO #11142.01)

Q Spring Creek Forest PUD (WCO #11192.01)

R Dove Meadows MUD (WCO #11215.01)

S Harris Co. WCID #110 Interim (WCO #11239.02)

T CNP Utility District (WCO #11239.03)

U Timberlake ID (WCO #11267.01)

V Candlelight Hills (WCO #11314.01)

X Cy-Champ PUD (WCO #11353.01)

Y Cypress-Klein UD (WCO #11366.01)

Z Kleinwood Central (WCO #11409.01)

AA Charterwood MUD (WCO #11410.01)

BB Harris Co. WCID #99 (WCO #11444.01)

CC Cypress-Fairbanks Matzke (WCO #11454.01)

DD Harris Co. MUD #29 (WCO #11527.01)

EE Northland Shopping Center (WCO #11572.01)

FF Harris County MUD #24 (WCO #11615.01)

GG Spring North Park (WCO #11656.01)

HH Harris County FWSD #52 (WCO #10528.01)

JJ Harris County WCID #91 (WCO #10732.01)

KK Harris County WCID #113 (WCO #10962.01)

Dischargers (continued)

LL Harris County WCID #119 (WCO #11024.01)

MM Inverness Forest ID (WCO #10783.01)

NN City of Waller (WCO #10310.01)

PP Waller County WCID #2 (WCO #11639.01)

RR Plains Machinery Company (WCO #11755.01)

TWQB and USGS Stations ▲

1 USGS 8069200 (Cypress Creek at Tettar Road)

2 TWQB 1009.005 (Cypress Creek at Aldine-Westfield Road)

3 USGS 8069000; TWQB 1009.01 (Cypress Creek at IH 45)

4 TWQB 1009.02 (Cypress Creek at Kuykendahl Road)

5 TWQB 1009.03 (Cypress Creek at Steubner-Airline Road)

6 USGS 8068750 (Cypress Creek at US 290)

7 USGS 8068740 (Cypress Creek at House-Haul Road)

8 USGS 8068720 (Cypress Creek at Katy-Hockley Road)

9 USGS 8068700 (Cypress Creek at Sharp Road)

City of Houston Sampling Stations ■

I Cypress Creek at Tettar Road

II Cypress Creek at Aldine-Westfield Road

III Cypress Creek at IH 45

IV Cypress Creek at Steubner-Airline Road

V Cypress Creek at FM 149

VI Cypress Creek at US 290

ATTACHMENT C

TWQB STREAM MONITORING DATA
CYPRESS CREEK

STATION NO. 1009.0050 — STATION LOCATION: CYPRESS CREEK AT ALDINE WESTFIELD ROAD

SAMPL. DATE	TIME	DEPTH (FT.)	SOURCE AGENCY	STREAM FLOW CFS	WATER TEMP FAHR	FEC COLI /100ML	DO MG/L	BOD 5 DAY MG/L	NH3-N TOTAL MG/L	T PO4 PO4 MG/L	CHLORPHYL A MG/L	PH SU	RESIDUE TOT NFLT MG/L	NO3-N TOTAL MG/L	CHLORIDE CL MG/L	SULFATE SO4 MG/L	RESIDUE DISS-SOR CON.MG/L	CNDUCTVY AT 25C MICROMHO	TURB JRSN JTU
07/14/75	1140	1.0	TWQB	45.0	83.0	1000.	7.5	2.0	1.000	.00			31.	.26	44.	40.	227.	350.	55.0
10/16/75	1355	1.0	TWQB	8.0	76.0	10.	8.8	4.0	1.500	.00	.005		15.	2.64	90.*	25.	421.*	950.	
01/12/76	1315	1.0	TWQB		61.0	8000.*	9.0	12.0	3.440		.000		11.	2.31	70.	28.		700.	
02/23/76	1200	1.0	TWQB		56.0	10.	10.1	5.0	5.000	.00	.000		25.	1.00	57.	39.		900.	
03/01/76	1210	1.0	TWQB	8.4	72.0		10.0		.050	.00			21.	9.97	92.*	35.	481.*	800.	
04/19/76	1325	1.0	TWQB		73.0	35000.*	7.6	8.0	.030	.00	.013		287.	.92	20.	22.	167.	240.	170.0
05/18/76	1115	1.0	TWQB		72.0	4000.*	7.2	7.0	.020	.00	.027		57.	2.89	42.	14.	306.*	450.	
06/15/76	1145	1.0	TWQB		83.0	350.	7.5	6.0	.080	.00	.044		36.	1.78	50.	14.	322.*	500.	
07/25/76	1145	1.0	TWQB		81.0	12000.*	6.9	4.0	.200	.00			230.	.49	27.	14.	181.	170.	205.0
08/09/76	1310	1.0	TWQB	7.0	87.0	850.	9.8	4.0	1.500	16.95	.027		12.	2.37	100.*	27.	469.*	700.	15.0
10/19/76	1145	1.0	TWQB		66.9	2500.*	8.8	5.0	.930	1.59	.003		7.	.14	550.*	9.		150.	90.0

STATION SUMMARY

AVERAGE	7.5		8.5	4.7	1.251	1.85	.015		27.	2.25	103.	24.	322.	537.	107.0
GEOMETRIC MEAN		100.													
MAXIMUM	87.0	35000.	10.	12.0	7.000	16.95	.044		287.	9.97	550.	40.	481.	950.	205.0
MINIMUM	56.0	10.	8.5	2.0	.020	.00	.000		7.	.14	20.	9.	167.	150.	15.0
SECOND HIGHEST SAMPLE	83.0	12000.	10.0	8.0	3.440	1.59	.027		230.	2.89	102.	39.	469.	900.	170.0
SECOND LOWEST SAMPLE	61.0	10.	7.0	4.0	.030	.00	.000		12.	.49	21.	14.	181.	170.	55.0
NUMBER OF SAMPLES	11	10	11	10	11	10	8		11	11	11	11	8	11	5

SEGMENT STANDARDS

EFFECTIVE DATE: 10/25/71 DEPTH: 1.0	STREAM FLOW CFS	WATER TEMP FAHR	FEC COLI /100ML	DO MG/L	BOD 5 DAY MG/L	NH3-N TOTAL MG/L	T PO4 PO4 MG/L	CHLORPHYL A MG/L	PH SU	RESIDUE TOT NFLT MG/L	NO3-N TOTAL MG/L	CHLORIDE CL MG/L	SULFATE SO4 MG/L	RESIDUE DISS-SOR CON.MG/L	CNDUCTVY AT 25C MICROMHO	TURB JRSN JTU
MAXIMUM		90.0	2000.						8.50			80.	40.	300.		
MINIMUM				5.0					6.50							

AN ASTERISK (*) DENOTES A MEASUREMENT THAT IS NOT WITHIN STANDARDS.

STATION NO. 1009.0100 — STATION LOCATION: BRIDGE 34 I. M. 67. 19 MILE NORTH OF MEDISTON

SAMPLE DATE	TIME	FLOW (MGD)	TEMP (C)	WATER TEMP (C)	FEC COLI /100ML	BOD MG/L	BOD 5 DAY MG/L	NO3-N TOTAL MG/L	T PO4 PO4 MG/L	CHLORPHYL A MG/L	PH SU	RESIDUE TOT NFLT MG/L	NO3-N TOTAL MG/L	CHLORIDE CL MG/L	SULFATE SO4 MG/L	RESIDUE DISS-FOR CON.MG/L	CNDUCTNY AT 25C MICROMHO	TURB JKSN JTU
10/06/71		3.0																
11/09/71		3.0		22		69.0	9.2	2.5										
01/24/72		3.0				56.0	8.2	3.2										
02/18/72	1435	3.0		20		71.0	6.1	9.0						37.	7.		270.	40.0
03/29/72	0900	3.0		27		49.0	9.6							37.	3.		170.	
04/25/72	0930	3.0		25		55.0	6.2	3.0	.170	3.30	.020	8.10	70.	.10	95.		432.	65.0
05/26/72	0930	3.0		13		72.0	5.2					8.00				270.		140.0
06/19/72	0910	3.0		1520		68.0	5.6					6.80				250.	700.	130.0
07/13/72	0930	3.0		908		73.0	5.4	1.7	.060	3.47	.020		105.	.01	11.	250.		70.0
08/22/72	0915	3.0		42		78.0	3.8					7.40					605.	250.0
09/27/72	0950	3.0		23		67.0	5.6					7.60						180.0
10/24/72	1000	3.0		22		70.0	5.2	9.0	.030	3.98	.011		120.	.07	69.		195.	270.0
11/27/72	0900	3.0		9.6		84.0	4.0					7.20						170.0
12/04/72	1020	3.0	7.0	114		75.0	5.0					7.10				190.		75.0
12/19/72	0900	3.0		30		67.0	13.3		1.000	1.61								220.0
01/11/73	0900	3.0		46		72.0	5.2					7.00		.42	24.		300.	
02/15/73	1129	3.0		270		65.0	6.7					8.10				270.		275.0
03/26/73	0940	3.0		2700		52.0	8.4	4.1	.080	2.45	.034		560.	.06	16.			140.0
04/12/73	1525	3.0		1370		61.0	6.4	3.0	.000	1.96	.037		560.	.06	7.	3.	225.	
05/28/73	1135	3.0		87		72.0	7.4	4.0	.007	2.94	.031		180.	.21	17.	4.	470.	
06/07/73	1100	3.0		24		74.0	5.2	5.1	.200	4.00	.029		440.	.30	15.	4.	162.	
07/30/73	1020	3.0		950		74.0	5.2	4.0	.380	1.7	.016		180.	.26	15.	4.	320.	
08/08/73	0925	3.0		33		64.0	7.4					7.00					135.	
09/18/73	0945	3.0	7.0	70		79.0	6.0	3.0	.230		.008		190.			160.		
10/10/73	0910	3.0	7.0	25		75.0	5.8	4.0	2.000	6.81			103.		30.	1.	420.	70.0
11/08/73	0900	3.0	7.0	2830		66.0	4.0					6.70					220.	45.0
12/06/73	0935	3.0	7.0	161		71.0	7.5					6.80				125.		60.0
01/17/74	0930	3.0	7.0	120		53.0	9.9		.000	7.62						110.		65.0
02/12/74	0945	3.0	7.0	95		52.0	10.4					6.80	134.	.36	28.		150.	80.0
03/07/74	0930	3.0	7.0	2.3		52.0	10.4		1.600	11.56						270.		50.0
04/30/74	0940	3.0	7.0	0.87		71.0	7.2		.100	10.42			300.	.60	30.		250.	75.0
05/13/74	0930	3.0	7.0	5.1		64.0	9.3		3.000	12.00	.000		8.	1.12	142.0	35.	340.	5.0
06/19/74	0900	3.0	7.0	684		77.0	6.2					6.70	2225.	4.10	81.0	34.	590.	
07/11/74	0940	3.0	7.0	9.0		85.0	6.0		1.400	14.40	.042		70.	3.90	90.	27.	665.	165.0
08/20/74	1035	3.0	7.0	39		80.0	7.5					7.20						
09/16/74	0920	3.0	7.0	1.7		83.0	6.7					7.00				125.		10.0
10/10/74	0930	3.0	7.0	4190		76.0	5.0		1.000	1.23			32.	1.00	33.	12.	115.	10.0
11/21/74	0900	3.0	7.0	23		72.0	6.2					7.40					80.	
12/24/74	1020	3.0	7.0	95		63.0	7.7					7.30				192.		45.0
01/29/75	0915	3.0	7.0	22		67.0	11.1		1.080	4.93			54.	.42	24.	21.	180.	40.0
02/11/75	0905	3.0	7.0	66		58.0	9.3					7.60					300.	
03/05/75	1155	3.0	7.0	100		75.0	10.4					7.20						140.0
04/02/75	0905	3.0	7.0	20		52.0	10.5		2.000	1.65			261.	.65	.	17.		180.0
04/24/75	1025	3.0	7.0	26		64.0	8.0					7.01					432.	
05/11/75	0950	3.0	7.0	24		83.0	6.7	2.0	1.000	1.50			176.	.23	17.	1.		140.0
06/23/75	1210	3.0	7.0	37		78.0	7.0		1.000	.00	.000		271.	.72	4.	1.	150.	
07/10/76	1020	3.0	7.0	5.7		56.0	9.5		4.100	.00	.000		21.	4.23	17.	17.	350.	
08/09/76	1000	3.0	7.0	67		59.0	8.8		.310	.00	.000		580.	.18	58.	46.	750.	
09/12/76	0920	3.0	7.0	39		79.0	6.7		.270	.60			86.	.90	25.	16.	350.	
10/13/76	0915	3.0	7.0	20		75.0	6.0	6.6	1.460	9.69			30.	.40	54.	9.	290.	
						50.0	10.2		.460	1.52	.004		15.	.13	17.	11.	500.	
					2700.*												100.	170.0

STATION SUMMARY

AVERAGE	68.2		7.2	6.4	.907	4.36	.012		247.	1.08	7.	18.	244.	347.	17.2
GEOMETRIC MEAN		99.													
MAXIMUM	85.0	19000.	11.3	9.0	6.100	14.40	.042	8.10	2225.	4.23	225.	40.	750.	750.	675.0
MINIMUM	47.0	0.	3.9	2.0	.000	.00	.000	6.70	8.	.01	6.	2.	180.	80.	10.0
SECOND HIGHEST SAMPLE	84.0	1900.	11.3	9.0	3.000	12.80	.026	8.10	580.	4.18	142.	37.	375.	750.	350.0
SECOND LOWEST SAMPLE	47.0	10.	4.0	2.5	.000	.00	.000	6.70	21.	.03	10.	8.	125.	100.	90.0
NUMBER OF SAMPLES	50	15	50	15	26	25	15	21	25	24	28	27	28	29	30

EFFECTIVE DATES 10/25/73 — SEGMENT STANDARDS

	STREAM FLOW CFS	WATER TEMP FAHR	FEC COLI /100ML	BOD MG/L	BOD 5 DAY MG/L	NO3-N TOTAL MG/L	T PO4 PO4 MG/L	CHLORPHYL A MG/L	PH SU	RESIDUE TOT NFLT MG/L	NO3-N TOTAL MG/L	CHLORIDE CL MG/L	SULFATE SO4 MG/L	RESIDUE DISS-FOR CON.MG/L	CNDUCTNY AT 25C MICROMHO	TURB JKSN JTU
MAXIMUM		90.0	2000.						8.50			80.	40.	300.		
MINIMUM				5.0					6.50							

** ASTERISK (*) FOR TEST & MEASUREMENT TYPE NOT WITHIN STANDARDS.

STATION NO. STATION LOCATION
AT HUGH REMPHL BLVD IN HOUSTON

SAMPLE DATE	TIME	DEPTH (FT.)	SOURCE AGENCY	STREAM FLOW CFS	WATER TEMP FAHR	FEC COLI /100ML	DO MG/L	BOD 5 DAY MG/L	NH3-N TOTAL MG/L	T PO4 PO4 MG/L	CHLOROPHYL A MG/L	PH SU	RESIDUE TOT NFLT MG/L	NO3-N TOTAL MG/L	CHLORIDE CL MG/L	SULFATE SO4 MG/L	RESIDUE DISS-SOL AT 25C CON.MG/L	CNDUCTVY AT 25C MICROMHO	TURB JKSN JTU
12/ 2/75	1235	1.0	TWQP	180	66.0	250.	6.9	1.0	1.200	.00	.000		192.	.16	37.	37.	157.	150.	140.0
01/27/76	0955	1.0	TWQP	4.0	56.0	190.	12.7	1.0	1.700	.01	.000		14.	1.61	8.	16.	261.*	400.	
03/22/76	1045	1.0	TWQP		59.0	10.	9.4	2.0	3.800		.000		27.	1.27	7.	28.		600.	
04/12/76	1100	1.0	TWQP		62.0	70.	10.2	1.0	1.440	.70	.019		68.	4.76	8.	46.*		500.	
05/11/76	1050	1.0	TWQP	9.0	70.0		7.6		.180	.00			19.	9.48	91.*	28.	464.*	850.	
06/15/76	1040	1.0	TWQP		79.0	4700.*	6.0	11.6	.060	.00	.040		81.	1.58	47.	25.	295.	500.	95.0
07/20/76	1045	1.0	TWQP			90.	7.0	7.0	.070	.00	.021		69.	2.52	67.	18.	261.	400.	
08/24/76	1115	1.0	TWQP		79.	640.*	7.8	5.0	.17	.07	.053		52.	.98	69.	12.	296.	400.	
09/27/76	1127	1.0	TWQP		70.	310.*	8.4	1.0	.130	.07			128.	.91	2.	8.	171.	180.	115.0
10/19/76	1120	1.0	TWQP	1.0	70.	270.	8.0	1.0	.350	1.00	.013		15.	2.90	110.*	22.	463.*	700.	15.0
12/19/76	1115	1.0	TWQP		56.	60.	9.0	4.0	.480	1.27	.004		88.	.20	35.	9.		150.	90.0
STATION SUMMARY																			
AVERAGE					72.0		9.0	5.0	.410	1.00	.020		80.	2.69	57.	21.	348.	458.	91.0
GEOMETRIC MEAN						410.													
MAXIMUM					87.0	4700.	12.6	11.6	3.80	.97	.053		192.	9.48	110.	46.	464.	850.	140.0
MINIMUM					52.0	10.	6.5	2.0	.120	.00	.000		14.	.20	10.	7.	157.	150.	15.0
STATION HIGHEST SAMPLE					84.0	4700.	12.0	10.0	1.440	1.20	.040		1.6.	9.74	91.	28.	463.	700.	115.0
STATION LOWEST SAMPLE					59.0	60.	6.5	2.0	.020	.00	.000		12.	.23	35.	9.	171.	150.	90.0
NUMBER OF SAMPLES						10	11	11	11	11	6		11	11	11	11	8	11	5
SEGMENT STANDARDS																			
EFFECTIVE DATES: 12/25/75				STREAM FLOW CFS	WATER TEMP FAHR	FEC COLI /100ML	DO MG/L	BOD 5 DAY MG/L	NH3-N TOTAL MG/L	T PO4 PO4 MG/L	CHLOROPHYL A MG/L	PH SU	RESIDUE TOT NFLT MG/L	NO3-N TOTAL MG/L	CHLORIDE CL MG/L	SULFATE SO4 MG/L	RESIDUE DISS-SOL AT 25C CON.MG/L	CNDUCTVY AT 25C MICROMHO	TURB JKSN JTU
MAXIMUM												8.50							
MINIMUM							5.0					6.50							

AN ASTERISK (*) DENOTES A MEASUREMENT THAT IS NOT WITHIN STANDARDS.

SEGMENT: EXPRESSWAY
COUNTY: HARRIS

STATION NO. STATION LOCATION
AT BRAESWOOD AVENUE ROAD IN HOUSTON

SAMPLE DATE	TIME	DEPTH (FT.)	SOURCE AGENCY	STREAM FLOW CFS	WATER TEMP FAHR	FEC COLI /100ML	DO MG/L	BOD 5 DAY MG/L	NH3-N TOTAL MG/L	T PO4 PO4 MG/L	CHLOROPHYL A MG/L	PH SU	RESIDUE TOT NFLT MG/L	NO3-N TOTAL MG/L	CHLORIDE CL MG/L	SULFATE SO4 MG/L	RESIDUE DISS-SOL CON.MG/L	CNDUCTVY AT 25C MICROMHO	TURB JKSN JTU
12/04/75	1125	1.0	TWQP	37.0	82.0	130.	7.5	2.0	1.000	.00			44.	.23	41.	22.	187.	300.	50.0
10/30/75	1200	1.0	TWQP	8.0	72.0	10.	8.0	4.0	1.800	.01	.000		12.	.97	81.	18.	382.*	650.	
01/27/76	1205	1.0	TWQP		59.0	10.	9.2	4.0	3.860		.000		16.	.78	67.	24.		600.	
02/23/76	1045	1.0	TWQP		52.0	10.	10.4	17.0	2.760	.00			84.	2.28	9.*	47.*		600.	
03/31/76	1055	1.0	TWQP	2.2	70.0		9.6		.120	.01			12.	9.06	96.*	27.	440.*	750.	
04/19/76	1210	1.0	TWQP		75.0	680.	7.7	12.0	.010	.07			55.	.89	67.	27.	315.*	500.	80.0
05/18/76	1135	1.0	TWQP		70.0	1600.	7.6	9.0	.080	.00	.013		52.	2.02	39.	21.	266.	350.	
06/15/76	1045	1.0	TWQP		83.0	730.	5.9	12.0	.025	.01	.027		52.	.48	49.	6.	287.	450.	
07/20/76	1055	1.0	TWQP		83.0	250.	6.9	2.0	.190	.00			178.	.46	30.	18.	198.	230.	115.0
08/30/76	1155	1.0	TWQP	3.0	84.0	20.	7.8	4.0	2.750	12.55	.007		9.	1.07	101.*	0.	444.*	700.	15.0
10/19/76	1055	1.0	TWQP		64.0	260.	9.0	2.0	.640	1.38	.005		146.	.09	35.			160.	80.0
STATION SUMMARY																			
AVERAGE					72.2		8.2	6.9	1.201	1.39	.009		58.	1.67	53.	21.	315.	481.	68.0
GEOMETRIC MEAN						103.													
MAXIMUM					84.0	1600.	10.4	17.0	3.840	12.55	.027		178.	9.06	102.	67.	444.	750.	115.0
MINIMUM					52.0	10.	5.9	2.0	.010	.00	.000		9.	.09	30.	0.	187.	160.	15.0
STATION HIGHEST SAMPLE					83.0	730.	9.4	12.0	2.760	1.38	.013		140.	2.28	96.	27.	440.	700.	80.0
STATION LOWEST SAMPLE					59.0	10.	6.9	2.0	.020	.00	.000		12.	.23	35.	6.	198.	230.	50.0
NUMBER OF SAMPLES					11	10	11	10	11	10	6		11	11	11	10	8	11	5
SEGMENT STANDARDS																			
EFFECTIVE DATES: 12/25/75				STREAM FLOW CFS	WATER TEMP FAHR	FEC COLI /100ML	DO MG/L	BOD 5 DAY MG/L	NH3-N TOTAL MG/L	T PO4 PO4 MG/L	CHLOROPHYL A MG/L	PH SU	RESIDUE TOT NFLT MG/L	NO3-N TOTAL MG/L	CHLORIDE CL MG/L	SULFATE SO4 MG/L	RESIDUE DISS-SOL CON.MG/L	CNDUCTVY AT 25C MICROMHO	TURB JKSN JTU
MAXIMUM					60.0	2000.						8.50			80.	40.	300.		
MINIMUM							5.0					6.50							

AN ASTERISK (*) DENOTES A MEASUREMENT THAT IS NOT WITHIN STANDARDS.

ATTACHMENT D

USGS STREAM MONITORING DATA
CYPRESS CREEK

SAN JACINTO RIVER BASIN

08068200 CYPRESS CREEK NEAR HUMBLE, TEX.

LOCATION.--Lat 30°01'09", long 95°19'47", Harris County, 400 feet north of end of dirt extension of Tetter Road, about 2 miles upstream from mouth, and 4.7 miles northwest of Humble.

DRAINAGE AREA.--319 sq mi.

PERIOD OF RECORD.--Chemical and biochemical analyses: October 1970 to September 1972.
Pesticide analyses: October 1970 to September 1972.

WATER-QUALITY DATA, OCTOBER 1970 TO SEPTEMBER 1972

DATE	TIME	DIS-CHARGE (CFS)	DIS-SOLVED SILICA (SiO2) (MG/L)	DIS-SOLVED CALCIUM (CA) (MG/L)	DIS-SOLVED MAGNESIUM (MG) (MG/L)	DIS-SOLVED SODIUM (NA) (MG/L)	BICARBONATE (HCO3) (MG/L)	CARBONATE (CO3) (MG/L)	DIS-SOLVED SULFATE (SO4) (MG/L)	DIS-SOLVED CHLORIDE (CL) (MG/L)	DIS-SOLVED FLUORIDE (F) (MG/L)	ORGANIC NITROGEN (N) (MG/L)
DEC.												
20...	1440	46	4.0	16	2.9	16	56	0	12	46	.2	.50
FEB.												
07...	1250	18	9.5	14	1.2	14	50	0	14	22	.2	.42
JUNE												
08...	1100	24	16	29	4.5	17	106	2	16	43	.1	.30
AUG.												
24...	1130	--	5.6	13	2.5	13	67	0	11	13	.2	.43

DATE	TOTAL NITRITE (N) (MG/L)	AMMONIA NITROGEN (N) (MG/L)	TOTAL NITRATE (N) (MG/L)	TOTAL PHOSPHORUS (P) (MG/L)	DIS-SOLVED SOLIDS (SUM OF CONSTI-TUENTS) (MG/L)	TOTAL SUS-PENDED SOLIDS (MG/L)	ORG. NITRO-GEN AND AMMONIA NITROGEN (MG/L)	HARD-NESS (CACO3 MG/L)	NON-CARB-ONATE HARD-NESS (MG/L)	SODIUM AD-SORP-TION RATIO	SPE-CIFIC CON-DUCT-ANCE (MICRO-MHOS)	PH (UNITS)
DEC.												
20...	.051	.29	.8	.62	156	154	70	47	1	2.1	267	6.7
FEB.												
07...	.015	.32	.6	.62	107	267	43	40	7	1.1	205	6.8
JUNE												
08...	.18	.18	.8	1.5	203	16	10	90	0	1.7	173	7.5
AUG.												
24...	.050	.29	.7	.65	95	418	60	42	4	.9	166	6.9

DATE	TEMPER-ATURE (DEG C)	COLOR (PLAT-INUM-COBALT UNITS)	TURB-IDITY (JTU)	DIS-SOLVED OXYGEN (MG/L)	PERCENT SATURA-TION	CHEM-ICAL OXYGEN DEMAND (MG/L)	BIO-CHEM-ICAL OXYGEN DEMAND (MG/L)	PHENOLS (UG/L)	METHY-LENE BLUE ACTIVE SUB-STANCE (MG/L)	DIS-SOLVED ALUM-INUM (AL) (UG/L)	DIS-SOLVED ARSENIC (AS) (UG/L)	DIS-SOLVED CAD-MIUM (CD) (UG/L)
DEC.												
20...	23.0	240	130	--	--	45	3.5	0	.00	240	0	0
FEB.												
07...	10.5	240	85	4.7	81	50	5.7	2	.00	188	0	0
JUNE												
08...	28.0	50	15	9.0	114	15	8.1	0	.01	30	0	0
AUG.												
24...	27.0	140	100	5.4	67	45	4.9	6	.00	100	0	0

DATE	DIS-SOLVED CHRO-MIUM (CR) (UG/L)	DIS-SOLVED COBALT (CO) (UG/L)	DIS-SOLVED COPPER (CU) (UG/L)	DIS-SOLVED IRON (FE) (UG/L)	DIS-SOLVED LEAD (PB) (UG/L)	DIS-SOLVED LITHIUM (LI) (UG/L)	DIS-SOLVED MAN-GANESE (MN) (UG/L)	DIS-SOLVED MERCURY (HG) (UG/L)	DIS-SOLVED NICKEL (NI) (UG/L)	DIS-SOLVED STRON-TIUM (SR) (UG/L)	DIS-SOLVED ZINC (ZN) (UG/L)
DEC.											
20...	0	0	15	530	0	0	0	.4	0	0	28
FEB.											
07...	0	0	17	630	0	0	40	<.2	0	120	30
JUNE											
08...	0	0	4	220	0	0	20	.2	0	120	58
AUG.											
24...	0	0	9	120	0	0	0	4.5	0	80	48

SAN JACINTO RIVER BASIN

08080300 CYPRESS CREEK NEAR HUMBLE, TEX.

LOCATION.--Lat 30°01'40", long 95°19'47", Harris County, 500 feet (153 m) north of end of dirt extension of Telter Road, about 2 miles (3 km) upstream from mouth, and 4.7 miles (7.8 km) northeast of Humble.

DRAINAGE AREA.--310 mi² (806 km²).

PERIOD OF RECORD.--Chemical and biochemical analyses: October 1970 to September 1973.
Pesticide analyses: October 1970 to September 1973.

WATER QUALITY DATA, WATER YEAR OCTOBER 1972 TO SEPTEMBER 1973

DATE	TIME	INSTANTANEOUS DISCHARGE (CFS)	DISSOLVED SILICA (SiO2) (MG/L)	DISSOLVED CALCIUM (CA) (MG/L)	DISSOLVED MAGNESIUM (MG) (MG/L)	DISSOLVED SODIUM (NA) (MG/L)	DISSOLVED SODIUM PLUS POTASSIUM (MG/L)	DISSOLVED POTASSIUM (K) (MG/L)	BICARBONATE (HCO3) (MG/L)	CARBONATE (CO3) (MG/L)	DISSOLVED SULFATE (SO4) (MG/L)	DISSOLVED CHLORIDE (CL) (MG/L)
OCT.												
27...	1300	85	9.6	14	3.2	--	21	--	57	0	12	26
FEB.												
05...	1300	30	6.3	16	3.2	--	20	--	60	0	14	33
APR.												
27...	1015	340	7.3	13	2.8	12	--	3.6	45	0	8.8	18
AUG.												
30...	1145	72	8.3	17	2.3	--	17	--	56	0	13	18

DATE	DISSOLVED FLUORIDE (F) (MG/L)	ORGANIC NITROGEN (N) (MG/L)	TOTAL NITRITE (N) (MG/L)	AMMONIA NITROGEN (N) (MG/L)	TOTAL NITRATE (N) (MG/L)	TOTAL PHOSPHORUS (P) (MG/L)	DISSOLVED SOLIDS (SUM OF CONSTITUENTS) (MG/L)	TOTAL NONFILTERABLE RESIDUE (MG/L)	VOL. NONFILTERABLE RESIDUE (MG/L)	HARDNESS (CaMg) (MG/L)	NONCARBONATE HARDNESS (MG/L)	SODIUM ADSORPTION RATIO
OCT.												
27...	.1	.31	.04	.19	.5	.42	114	480	380	68	1	1.3
FEB.												
05...	.2	.36	.07	.37	.9	.00	139	148	54	58	9	1.5
APR.												
27...	.1	.77	.04	.36	.6	.68	91	380	68	46	7	.8
AUG.												
30...	.2	.38	.05	.23	1.3	.75	104	561	85	57	8	1.0

DATE	SPECIFIC CONDUCTANCE (MICROMHOS)	PH (UNITS)	TEMPERATURE (DEG C)	COLOR (PLATINUM-COBALT UNITS)	TURBIDITY (JTU)	DISSOLVED OXYGEN (MG/L)	PERCENT SATURATION	BIOCHEMICAL OXYGEN DEMAND (MG/L)	TOTAL ORGANIC CARBON (C) (MG/L)	DISSOLVED ALUMINUM (AL) (UG/L)	DISSOLVED ARSENIC (AS) (UG/L)
OCT.											
27...	227	6.5	17.5	--	--	9.6	98	3.2	20	240	0
FEB.											
05...	255	6.5	17.0	240	90	9.1	96	3.0	20	270	0
APR.											
27...	142	6.3	21.0	240	170	6.9	77	5.2	--	--	--
AUG.											
30...	203	6.7	21.5	240	340	6.6	78	5.3	25	210	2

DATE	DISSOLVED CADMIUM (CD) (UG/L)	DISSOLVED CHROMIUM (CR) (UG/L)	DISSOLVED COBALT (CO) (UG/L)	DISSOLVED COPPER (CU) (UG/L)	DISSOLVED IRON (FE) (UG/L)	DISSOLVED LEAD (PB) (UG/L)	DISSOLVED LITHIUM (LI) (UG/L)	DISSOLVED MANGANESE (MN) (UG/L)	DISSOLVED NICKEL (NI) (UG/L)	DISSOLVED STRONTIUM (SR) (UG/L)	DISSOLVED ZINC (ZN) (UG/L)
OCT.											
27...	1	0	0	6	100	0	0	10	4	100	50
FEB.											
05...	1	0	0	0	600	0	0	40	17	90	20
APR.											
27...	--	--	--	--	--	--	--	--	--	--	--
AUG.											
30...	0	0	0	--	210	0	0	0	5	200	--

SAN JACINTO RIVER BASIN

OWEN'S CYPRESS CREEK NEAR HUMBLE, TEX.

LOCATION.--Lat 30°00'00", Long 95°09'07", Harris County, 500 ft (152 m) north of end of dirt extension of Tetter Road, about 2 miles (3 km) upstream from mouth, and 4.7 miles (7.6 km) northwest of Humble.

DRAINAGE AREA.--[illegible] ([illegible] km²).

PERIOD OF RECORD.--Chemical and biochemical analyses, October 1971 to September 1974.
Pesticide analyses, October 1970 to September 1974.

WATER QUALITY DATA, WATER YEAR OCTOBER 1973 TO SEPTEMBER 1974

DATE	TIME	INSTANTANEOUS DISCHARGE (CFS)	DISSOLVED SILICA (SIO2) (MG/L)	DISSOLVED CALCIUM (CA) (MG/L)	DISSOLVED MAGNESIUM (MG) (MG/L)	DISSOLVED SODIUM (NA) (MG/L)	DISSOLVED SODIUM PLUS POTASSIUM (MG/L)	DISSOLVED POTASSIUM (K) (MG/L)	BICARBONATE (HCO3) (MG/L)	CARBONATE (CO3) (MG/L)	DISSOLVED SULFATE (SO4) (MG/L)	DISSOLVED CHLORIDE (CL) (MG/L)
NOV.												
01...	0900	--	8.8	10	1.7	--	9.2	--	32	0	8.2	12
FEB.												
15...	1300	29	14	30	5.4	--	38	--	100	0	18	54
MAY												
07...	1300	9.1	13	39	6.5	90	--	6.7	100	0	33	89

DATE	DISSOLVED FLUORIDE (F) (MG/L)	TOTAL NITRATE (N) (MG/L)	TOTAL NITRITE (N) (MG/L)	AMMONIA NITROGEN (N) (MG/L)	ORGANIC NITROGEN (N) (MG/L)	TOTAL KJELDAHL NITROGEN (N) (MG/L)	TOTAL PHOSPHORUS (P) (MG/L)	DISSOLVED SOLIDS (SUM OF CONSTITUENTS) (MG/L)	TOTAL NONFILTRABLE RESIDUE (MG/L)	VOL. NONFILTRABLE RESIDUE (MG/L)	HARDNESS (CA,MG) (MG/L)
NOV.											
01...	.1	.20	.00	.21	.38	--	.33	67	236	21	32
FEB.											
15...	.2	.00	.32	.75	.43	--	1.6	214	122	40	97
MAY											
07...	--	3.0	.40	.19	1.0	1.4	3.1	367	52	16	120

DATE	NONCARBONATE HARDNESS (MG/L)	SODIUM ADSORPTION RATIO	SPECIFIC CONDUCTANCE (MICROMHOS)	PH (UNITS)	TEMPERATURE (DEG C)	COLOR (PLATINUM-COBALT UNITS)	TURBIDITY (JTU)	DISSOLVED OXYGEN (MG/L)	PERCENT SATURATION	BIOCHEMICAL OXYGEN DEMAND (MG/L)	TOTAL ORGANIC CARBON (C) (MG/L)
NOV.											
01...	6	.7	115	6.6	14.0	200	100	8.0	77	4.1	22
FEB.											
15...	15	1.7	425	6.9	18.0	60	70	7.0	74	2.9	--
MAY											
07...	0	3.5	699	7.6	24.0	40	20	6.7	79	7.5	--

DATE	TIME	DISSOLVED ALUMINUM (AL) (UG/L)	DISSOLVED BERYLLIUM (BE) (UG/L)	DISSOLVED BORON (B) (UG/L)	DISSOLVED CADMIUM (CD) (UG/L)	DISSOLVED CHROMIUM (CR) (UG/L)	DISSOLVED COBALT (CO) (UG/L)	DISSOLVED COPPER (CU) (UG/L)
NOV.								
01...	0900	460	1	--	0	0	0	5
FEB.								
15...	1300	110	4	--	0	0	0	6
MAY								
07...	1300	80	4	310	1	0	5	8

DATE	DISSOLVED IRON (FE) (UG/L)	DISSOLVED LEAD (PB) (UG/L)	DISSOLVED LITHIUM (LI) (UG/L)	DISSOLVED MANGANESE (MN) (UG/L)	DISSOLVED MERCURY (HG) (UG/L)	DISSOLVED NICKEL (NI) (UG/L)	DISSOLVED STRONTIUM (SR) (UG/L)	DISSOLVED ZINC (ZN) (UG/L)
NOV.								
01...	400	0	0	0	.2	0	60	20
FEB.								
15...	60	1	0	0	.6	0	110	80
MAY								
07...	70	20	10	60	.1	10	240	40

SAN JACINTO RIVER BASIN

08069200 Cypress Creek near Humble, Tex.
(Reconnaissance partial-record station)

LOCATION.--Lat 30°01'49", long 95°19'47", Harris County, 500 ft (150 m) north of end of dirt extension of Tatter Road, about 2 miles (3 km) upstream from mouth, and 4.7 miles (7.6 km) northwest of Humble.

DRAINAGE AREA.--319 mi^2 (826 km^2).

PERIOD OF RECORD.--Occasional discharge measurements and water-quality data: October 1970 to current year.

DISCHARGE AND WATER QUALITY DATA, WATER YEAR OCTOBER 1974 TO SEPTEMBER 1975

DATE	TIME	INSTANTANEOUS DISCHARGE (CFS)	DISSOLVED SILICA (SiO_2) (MG/L)	DISSOLVED CALCIUM (CA) (MG/L)	DISSOLVED MAGNESIUM (MG) (MG/L)	DISSOLVED SODIUM (NA) (MG/L)	DISSOLVED POTASSIUM (K) (MG/L)	BICARBONATE (HCO_3) (MG/L)	CARBONATE (CO_3) (MG/L)	DISSOLVED SULFATE (SO_4) (MG/L)	DISSOLVED CHLORIDE (CL) (MG/L)
OCT.											
21...	1000	24	16	20	3.0	48	7.5	92	0	17	50
MAR.											
19...	1305	--	3.1	7.9	1.5	12	3.4	19	0	12	18
MAY											
23...	1030	13	17	31	5.1	63	5.6	130	0	25	68
SEP.											
24...	0930	15	17	32	5.2	87	8.4	180	0	32	86

DATE	DISSOLVED FLUORIDE (F) (MG/L)	TOTAL NITRATE (N) (MG/L)	TOTAL NITRITE (N) (MG/L)	AMMONIA NITROGEN (N) (MG/L)	TOTAL ORGANIC NITROGEN (N) (MG/L)	TOTAL KJELDAHL NITROGEN (N) (MG/L)	TOTAL PHOSPHORUS (P) (MG/L)	DISSOLVED SOLIDS (SUM OF CONSTITUENTS) (MG/L)	TOTAL NONFILTRABLE RESIDUE (MG/L)	VOL. NONFILTRABLE RESIDUE (MG/L)	HARDNESS (CA,MG) (MG/L)
OCT.											
21...	--	1.7	.12	.21	1.4	1.6	1.7	208	90	23	62
MAR.											
19...	.2	.25	.02	.22	1.9	2.1	.41	68	812	114	26
MAY											
23...	.3	2.7	.21	.08	1.9	2.0	3.0	279	95	6	98
SEP.											
24...	--	1.6	.22	.39	1.7	2.1	3.0	357	84	32	100

DATE	NONCARBONATE HARDNESS (MG/L)	SODIUM ADSORPTION RATIO	SPECIFIC CONDUCTANCE (MICROMHOS)	PH (UNITS)	TEMPERATURE (DEG C)	COLOR (PLATINUM-COBALT UNITS)	TURBIDITY (JTU)	DISSOLVED OXYGEN (MG/L)	PERCENT SATURATION	BIOCHEMICAL OXYGEN DEMAND 5 DAY (MG/L)	TOTAL ORGANIC CARBON (C) (MG/L)
OCT.											
21...	0	2.6	385	6.3	20.0	70	55	6.1	88	2.2	16
MAR.											
19...	10	1.0	131	6.0	10.0	240	140	6.5	89	4.3	--
MAY											
23...	0	2.8	523	6.8	26.5	50	50	6.2	76	3.1	7.6
SEP.											
24...	0	3.8	659	7.1	26.0	60	35	6.3	80	2.5	13

[illegible]

[illegible]

WATER QUALITY DATA, [illegible] YEAR [illegible]

DATE	TIME	DISCHARGE (CFS)	DISSOLVED SILICA (MG/L)	DISSOLVED CALCIUM (CA) (MG/L)	DISSOLVED MAGNESIUM (MG) (MG/L)	DISSOLVED SODIUM (NA) (MG/L)	DISSOLVED POTASSIUM (K) (MG/L)	BICARBONATE (HCO3) (MG/L)	CARBONATE (CO3) (MG/L)	DISSOLVED SULFATE (SO4) (MG/L)	DISSOLVED CHLORIDE (CL) (MG/L)
JAN.											
22...	1451	8.0	19	39	6.1	110	16	214	0	48	96
APR.											
21...	1310	[illegible]	6.6	13	2.1	14	2.4	52	0	8.6	13
SEP.											
01...	2045	--	1.9	3.5	.5	3.7	2.7	15	0	4.3	6.6

DATE	DISSOLVED FLUORIDE (F) (MG/L)	TOTAL NITRATE (N) (MG/L)	TOTAL NITRITE (N) (MG/L)	TOTAL AMMONIA NITROGEN (N) (MG/L)	TOTAL ORGANIC NITROGEN (N) (MG/L)	TOTAL PHOSPHORUS (P) (MG/L)	DISSOLVED SOLIDS (SUM OF CONSTITUENTS) (MG/L)	TOTAL NONFILTRABLE RESIDUE (MG/L)	VOL. NONFILTRABLE RESIDUE (MG/L)	HARDNESS (CA,MG) (MG/L)	NONCARBONATE HARDNESS (MG/L)
JAN.											
22...	.4	.60	.08	3.1	3.9	5.3	434	15	1	120	0
APR.											
21...	.4	.30	.08	.37	1.3	.64	86	214	24	41	0
SEP.											
01...	.1	.35	.02	.14	1.2	.35	31	420	152	11	0

DATE	SODIUM ADSORPTION RATIO	SPECIFIC CONDUCTANCE (MICROMHOS)	PH (UNITS)	TEMPERATURE (DEG C)	COLOR (PLATINUM-COBALT UNITS)	TURBIDITY (JTU)	DISSOLVED OXYGEN (MG/L)	PERCENT SATURATION	BIOCHEMICAL OXYGEN DEMAND 5 DAY (MG/L)	TOTAL ORGANIC CARBON (C) (MG/L)
JAN.										
22...	4.3	769	7.5	11.0	30	10	10.2	92	--	6.8
APR.										
21...	1.0	167	8.8	21.5	160	110	6.7	74	4.9	11
SEP.										
01...	.5	61	6.4	24.0	240	200	6.8	83	3.9	8.1

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY
[illegible] - [illegible]

WATER QUALITY DATA, WATER YEAR OCTOBER 1975 TO SEPTEMBER 1976

DATE	TIME	DIS-SOLVED ALUM-INUM (AL) (UG/L)	DIS-SOLVED ARSENIC (AS) (UG/L)	DIS-SOLVED BORON (B) (UG/L)	DIS-SOLVED CAD-MIUM (CD) (UG/L)	DIS-SOLVED CHROM-IUM (CR) (UG/L)	DIS-SOLVED COBALT (CO) (UG/L)	DIS-SOLVED COPPER (CU) (UG/L)
JAN.								
22...	1450	10	4	340	0	0	0	4
APR.								
21...	1000	10	2	110	1	0	0	3
SEP.								
01...	0945	40	4	40	0	0	0	3

DATE	DIS-SOLVED IRON (FE) (UG/L)	DIS-SOLVED LEAD (PB) (UG/L)	DIS-SOLVED LITHIUM (LI) (UG/L)	DIS-SOLVED MAN-GANESE (MN) (UG/L)	DIS-SOLVED MER-CURY (HG) (UG/L)	DIS-SOLVED NICKEL (NI) (UG/L)	DIS-SOLVED STRON-TIUM (SR) (UG/L)	DIS-SOLVED ZINC (ZN) (UG/L)
JAN.								
22...	40	0	20	0	.2	0	280	40
APR.								
21...	100	0	0	10	.1	0	60	10
SEP.								
01...	60	2	0	20	.3	3	50	30

DATE	TIME	INSTAN-TANEOUS DIS-CHARGE (CFS)	TEMPER-ATURE (DEG C)	TOTAL ALDRIN (UG/L)	TOTAL CHLOR-DANE (UG/L)	TOTAL DDD (UG/L)	TOTAL DDE (UG/L)	TOTAL DDT (UG/L)	TOTAL DI-AZINON (UG/L)
JAN.									
22...	1450	8.0	11.0	.00	.0	.00	.00	.00	.29
APR.									
21...	1000	40	20.5	.00	.0	.00	.00	.00	.11
SEP.									
01...	0945	--	24.0	.00	.1	.00	.00	.00	.10

DATE	TOTAL DI-ELDRIN (UG/L)	TOTAL ENDRIN (UG/L)	TOTAL ETHION (UG/L)	TOTAL HEPTA-CHLOR (UG/L)	TOTAL HEPTA-CHLOR EPOXIDE (UG/L)	TOTAL LINDANE (UG/L)	TOTAL MALA-THION (UG/L)	TOTAL METHYL PARA-THION (UG/L)	TOTAL METHYL TRI-THION (UG/L)
JAN.									
22...	.00	.00	.00	.00	.00	.05	.00	.00	.00
APR.									
21...	.01	.00	.00	.00	.01	.10	.04	.00	.00
SEP.									
01...	.01	.00	.00	.00	.02	.29	.07	.00	.00

DATE	TOTAL PARA-THION (UG/L)	TOTAL PCB (UG/L)	POLY-CHLO-RINATED NAPH-THA-LENES (UG/L)	TOTAL TOX-APHENE (UG/L)	TOTAL TRI-THION (UG/L)	TOTAL 2,4-D (UG/L)	TOTAL 2,4,5-T (UG/L)	TOTAL SILVER (UG/L)
JAN.								
22...	.00	.0	--	0	.00	.00	.00	.00
APR.								
21...	.00	.0	.00	0	.00	.00	.00	.00
SEP.								
01...	.00	.0	.00	0	.00	.00	.07	.00

SAN JACINTO RIVER BASIN

08068750 CYPRESS CREEK NEAR CYPRESS, TEX.

LOCATION.--Lat 29°57'23", long 95°48'41", Harris County, at bridge on U.S. Highway 290, 1.5 miles southeast of Cypress.

DRAINAGE AREA.--138 sq mi.

PERIOD OF RECORD.--Chemical and biochemical analyses, October 1970 to September 1972.
Pesticide analyses, October 1970 to September 1972.

WATER QUALITY DATA, WATER YEAR OCTOBER 1971 TO SEPTEMBER 1972

DATE	TIME	DIS-CHARGE (CFS)	DIS-SOLVED SILICA (SIO2) (MG/L)	DIS-SOLVED CAL-CIUM (CA) (MG/L)	DIS-SOLVED MAG-NE-SIUM (MG) (MG/L)	DIS-SOLVED SODIUM PLUS POTAS-SIUM (MG/L)	BICAR-BONATE (HCO3) (MG/L)	CAR-BONATE (CO3) (MG/L)	DIS-SOLVED SULFATE (SO4) (MG/L)	DIS-SOLVED CHLO-RIDE (CL) (MG/L)	DIS-SOLVED FLUO-RIDE (F) (MG/L)	ORGANIC NITRO-GEN (N) (MG/L)
DEC.												
20...	1045	27	7.5	13	2.8	13	52	0	9.2	43	.2	.52
FEB.												
07...	1000	20	5.1	12	1.2	25	96	0	18	34	.2	.41
MAR												
08...	1000	19	2.1	20	1.1	29	68	1[illegible]	1.2	41	.3	.68
AUG.												
24...	1000	1.2	16	21	1.0	130	124	0	10	180	.3	.53

DATE	TOTAL NITRITE (N) (MG/L)	AMMONIA NITRO-GEN (N) (MG/L)	TOTAL NITRATE (N) (MG/L)	TOTAL PHOS-PHORUS (P) (MG/L)	DIS-SOLVED SOLIDS (SUM OF CONSTI-TUENTS) (MG/L)	TOTAL NON-FILT-ABLE RESIDUE (MG/L)	VOL. NON-SETTLE-ABLE RESIDUE (MG/L)	HARD-NESS (CA,MG) (MG/L)	NON-CAR-BONATE HARD-NESS (MG/L)	SODIUM AD-SORP-TION RATIO	SPE-CIFIC CON-DUCT-ANCE (MICRO-MHOS)	PH (UNITS)
DEC.												
20...	.026	.05	.6	.27	137	222	49	44	1	2.2	268	6.6
FEB.												
07...	.008	.20	.6	.31	118	175	41	43	14	1.7	233	7.8
MAR												
08...	.011	.15	.1	.27	138	128	24	63	0	1.6	282	7.4
AUG.												
24...	.010	.19	.1	.32	411	1600	196	80	0	6.4	742	7.3

DATE	TEMPER-ATURE (DEG C)	COLOR (PLAT-INUM-COBALT UNITS)	TUR-BID-ITY (JTU)	DIS-SOLVED OXYGEN (MG/L)	PER-CENT SATUR-ATION	CHEM-ICAL OXYGEN DEMAND (LOW LEVEL) (MG/L)	BIO-CHEM-ICAL OXYGEN DEMAND (MG/L)	PHENOLS (UG/L)	METHY-LENE BLUE ACTIVE SUB-STANCE (MG/L)	DIS-SOLVED ALUM-INUM (AL) (UG/L)	DIS-SOLVED ARSENIC (AS) (UG/L)	DIS-SOLVED CAD-MIUM (CD) (UG/L)
DEC.												
20...	17.0	60	160	--	--	55	5.7	0	.00	260	0	0
FEB.												
07...	9.5	280	110	9.8	96	53	5.3	2	.00	390	0	0
MAR												
08...	28.0	15	60	9.0	114	44	8.1	0	.00	10	0	0
AUG.												
24...	28.5	280	470	4.4	56	45	2.6	5	.00	100	0	0

DATE	DIS-SOLVED CHROM-IUM (CR) (UG/L)	DIS-SOLVED COBALT (CO) (UG/L)	DIS-SOLVED COPPER (CU) (UG/L)	DIS-SOLVED IRON (FE) (UG/L)	DIS-SOLVED LEAD (PB) (UG/L)	DIS-SOLVED LITHIUM (LI) (UG/L)	DIS-SOLVED MAN-GANESE (MN) (UG/L)	DIS-SOLVED MERCURY (HG) (UG/L)	DIS-SOLVED NICKEL (NI) (UG/L)	DIS-SOLVED STRON-TIUM (SR) (UG/L)	DIS-SOLVED ZINC (ZN) (UG/L)
DEC.											
20...	0	0	21	540	0	0	0	.1	0	70	80
FEB.											
07...	0	0	15	1100	0	0	0	<.2	0	70	10
MAR											
08...	0	0	4	10	0	0	20	1.1	0	150	50
AUG.											
24...	0	0	9	270	0	20	0	>.2	3	160	40

SAN JACINTO RIVER BASIN

08068750 CYPRESS CREEK NEAR CYPRESS, TEX.

LOCATION.--Lat 29°57'23", long 95°40'41", Harris County, at bridge on U.S. Highway 290, 1.5 miles (2.4 km) southeast of Cypress

DRAINAGE AREA.--138 mi^2 (357 km^2)

PERIOD OF RECORD.--Chemical and biochemical analyses: October 1970 to September 1973
Pesticide analyses: October 1970 to September 1973

WATER QUALITY DATA, WATER YEAR OCTOBER 1972 TO SEPTEMBER 1973

DATE	TIME	INSTANTANEOUS DISCHARGE (CFS)	DISSOLVED SILICA (SIO2) (MG/L)	DISSOLVED CALCIUM (CA) (MG/L)	DISSOLVED MAGNESIUM (MG) (MG/L)	DISSOLVED SODIUM (NA) (MG/L)	DISSOLVED SODIUM PLUS POTASSIUM (MG/L)	DISSOLVED POTASSIUM (K) (MG/L)	BICARBONATE (HCO3) (MG/L)	CARBONATE (CO3) (MG/L)	DISSOLVED SULFATE (SO4) (MG/L)	DISSOLVED CHLORIDE (CL) (MG/L)
OCT.												
27...	1000	26	14	14	3.7	--	39	--	71	0	12	46
FEB.												
05...	1000	12	6.1	19	3.3	--	39	--	60	0	21	52
APR.												
26...	1225	85	5.9	11	1.1	9.2	--	3.1	38	0	7.4	14
AUG.												
30...	0915	40	9.2	18	5.9	--	16	--	72	0	9.2	24

DATE	DISSOLVED FLUORIDE (F) (MG/L)	ORGANIC NITROGEN (N) (MG/L)	TOTAL NITRITE (N) (MG/L)	AMMONIA NITROGEN (N) (MG/L)	TOTAL NITRATE (N) (MG/L)	TOTAL PHOSPHORUS (P) (MG/L)	DISSOLVED SOLIDS (RESIDUE AT 180 C) (MG/L)	DISSOLVED SOLIDS (SUM OF CONSTITUENTS) (MG/L)	TOTAL NONFILTRABLE RESIDUE (MG/L)	VOL. NONFILTRABLE RESIDUE (MG/L)	HARDNESS (CA,MG) (MG/L)	NONCARBONATE HARDNESS (MG/L)
OCT.												
27...	.0	.35	.01	.05	.1	.30	93	164	75	--	50	0
FEB.												
05...	.2	.38	.02	.11	.4	.18	--	173	178	42	61	12
APR.												
26...	.2	.63	.03	.41	.4	.37	--	73	293	50	32	1
AUG.												
30...	.1	.19	.01	.05	.1	.50	--	118	160	28	69	10

DATE	SODIUM ADSORPTION RATIO	SPECIFIC CONDUCTANCE (MICROMHOS)	PH (UNITS)	TEMPERATURE (DEG C)	COLOR (PLATINUM-COBALT UNITS)	TURBIDITY (JTU)	DISSOLVED OXYGEN (MG/L)	PERCENT SATURATION	BIOCHEMICAL OXYGEN DEMAND (MG/L)	TOTAL ORGANIC CARBON (C) (MG/L)	DISSOLVED ALUMINUM (AL) (UG/L)	DISSOLVED ARSENIC (AS) (UG/L)
OCT.												
27...	2.4	307	6.4	14.5	--	--	9.8	95	3.0	20	100	0
FEB.												
05...	2.2	321	6.2	17.5	280	110	10.2	106	4.1	20	260	0
APR.												
26...	.7	129	6.6	25.5	160	120	7.2	87	4.5	--	--	--
AUG.												
30...	.8	236	6.5	24.5	50	66	7.2	86	4.5	21	40	0

DATE	DISSOLVED CADMIUM (CD) (UG/L)	DISSOLVED CHROMIUM (CR) (UG/L)	DISSOLVED COBALT (CO) (UG/L)	DISSOLVED COPPER (CU) (UG/L)	DISSOLVED IRON (FE) (UG/L)	DISSOLVED LEAD (PB) (UG/L)	DISSOLVED LITHIUM (LI) (UG/L)	DISSOLVED MANGANESE (MN) (UG/L)	DISSOLVED NICKEL (NI) (UG/L)	DISSOLVED STRONTIUM (SR) (UG/L)	DISSOLVED ZINC (ZN) (UG/L)
OCT.											
27...	0	0	0	3	300	0	0	0	4	120	30
FEB.											
05...	0	0	0	6	500	0	0	0	0	100	20
APR.											
26...	--	--	--	--	--	--	--	--	--	--	--
AUG.											
30...	0	0	0	4	130	0	0	0	0	170	140

SAN JACINTO RIVER BASIN

08068750 CYPRESS CREEK NEAR CYPRESS, TEX.

LOCATION.--Lat 29°57'23", long 95°40'41", Harris County, at bridge on U.S. Highway 290 and 1.5 miles (2.4 km) southeast of Cypress.

DRAINAGE AREA.--138 mi² (357 km²).

PERIOD OF RECORD.--Chemical and biochemical analyses: October 1970 to September 1974.
Pesticide analyses: October 1970 to September 1974.

WATER QUALITY DATA, WATER YEAR OCTOBER 1973 TO SEPTEMBER 1974

DATE	TIME	INSTANTANEOUS DISCHARGE (CFS)	DISSOLVED SILICA (SIO2) (MG/L)	DISSOLVED CALCIUM (CA) (MG/L)	DISSOLVED MAGNESIUM (MG) (MG/L)	DISSOLVED SODIUM (NA) (MG/L)	DISSOLVED SODIUM PLUS POTASSIUM (MG/L)	DISSOLVED POTASSIUM (K) (MG/L)	BICARBONATE (HCO3) (MG/L)	CARBONATE (CO3) (MG/L)	DISSOLVED SULFATE (SO4) (MG/L)
NOV.											
01...	1230	260	8.7	7.5	2.1	--	7.0	--	23	0	8.4
FEB.											
15...	1000	6.7	8.5	27	5.5	--	54	--	65	0	26
MAY											
02...	0930	1.6	5.7	40	6.2	130	--	5.9	130	0	46

DATE	DISSOLVED CHLORIDE (CL) (MG/L)	DISSOLVED FLUORIDE (F) (MG/L)	TOTAL NITRATE (N) (MG/L)	TOTAL NITRITE (N) (MG/L)	AMMONIA NITROGEN (N) (MG/L)	ORGANIC NITROGEN (N) (MG/L)	TOTAL PHOSPHORUS (P) (MG/L)	DISSOLVED SOLIDS (SUM OF CONSTITUENTS) (MG/L)	TOTAL NONFILTRABLE RESIDUE (MG/L)	VOL. NONFILTRABLE RESIDUE (MG/L)	HARDNESS (CA,MG) (MG/L)
NOV.											
01...	12	.1	.20	.03	.15	.45	.29	59	218	12	30
FEB.											
15...	90	.2	.30	.00	.14	.55	.37	245	229	44	90
MAY											
02...	180	--	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	479	[illegible]	26	130

DATE	NONCARBONATE HARDNESS (MG/L)	SODIUM ADSORPTION RATIO	SPECIFIC CONDUCTANCE (MICROMHOS)	PH (UNITS)	TEMPERATURE (DEG C)	COLOR (PLATINUM-COBALT UNITS)	TURBIDITY (JTU)	DISSOLVED OXYGEN (MG/L)	PERCENT SATURATION	BIOCHEMICAL OXYGEN DEMAND (MG/L)	TOTAL ORGANIC CARBON (C) (MG/L)
NOV.											
01...	11	.6	109	6.4	15.0	160	95	7.6	75	4.1	26
FEB.											
15...	37	2.5	486	7.1	17.5	200	120	8.6	90	2.4	--
MAY											
02...	19	5.1	915	7.6	22.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	--

DATE	TIME	DISSOLVED ALUMINUM (AL) (UG/L)	DISSOLVED ARSENIC (AS) (UG/L)	DISSOLVED BORON (B) (UG/L)	DISSOLVED CADMIUM (CD) (UG/L)	DISSOLVED CHROMIUM (CR) (UG/L)	DISSOLVED COBALT (CO) (UG/L)	DISSOLVED COPPER (CU) (UG/L)
NOV.								
01...	1230	420	1	--	0	0	0	[illegible]
FEB.								
15...	1000	160	0	--	0	0	0	[illegible]
MAY								
02...	0930	120	1	230	1	0	1	[illegible]

DATE	DISSOLVED IRON (FE) (UG/L)	DISSOLVED LEAD (PB) (UG/L)	DISSOLVED LITHIUM (LI) (UG/L)	DISSOLVED MANGANESE (MN) (UG/L)	DISSOLVED MERCURY (HG) (UG/L)	DISSOLVED NICKEL (NI) (UG/L)	DISSOLVED STRONTIUM (SR) (UG/L)	DISSOLVED ZINC (ZN) (UG/L)
NOV.								
01...	500	0	0	0	[illegible]	0	0	20
FEB.								
15...	120	1	0	50	.0	1	110	--
MAY								
02...	80	10	20	0	.1	12	230	40

08068750 Cypress Creek near Cypress, Tex.
(Reconnaissance partial record station)

LOCATION.--Lat 29°57'23", long 95°40'41", Harris County, at bridge on U.S. Highway 290 and 1.5 miles (2.4 km) southeast of Cypress.

DRAINAGE AREA 138 mi² (357 km²).

PERIOD OF RECORD.--Occasional discharge measurements and water quality data [illegible]ber 1970 to current year.

DISCHARGE AND WATER QUALITY DATA, WATER YEAR OCTOBER 1974 TO SEPTEMBER 1975

DATE	TIME	INSTANTANEOUS DISCHARGE (CFS)	DISSOLVED SILICA (SIO2) (MG/L)	DISSOLVED CALCIUM (CA) (MG/L)	DISSOLVED MAGNESIUM (MG) (MG/L)	DISSOLVED SODIUM (NA) (MG/L)	DISSOLVED POTASSIUM (K) (MG/L)	BICARBONATE (HCO3) (MG/L)	CARBONATE (CO3) (MG/L)	DISSOLVED SULFATE (SO4) (MG/L)	DISSOLVED CHLORIDE (CL) (MG/L)
OCT.											
21...	1200	7.4	16	17	1.2	41	6.3	80	0	6.8	58
MAR.											
20...	1430	138	4.0	7.6	2.1	9.3	4.0	25	0	12	13
MAY											
23...	1245	--	16	24	4.8	63	3.8	94	0	16	84
SEP.											
24...	1330	6.6	26	27	4.6	66	7.2	140	0	18	78

DATE	DISSOLVED FLUORIDE (F) (MG/L)	TOTAL NITRATE (N) (MG/L)	TOTAL NITRITE (N) (MG/L)	AMMONIA NITROGEN (N) (MG/L)	TOTAL ORGANIC NITROGEN (N) (MG/L)	TOTAL KJELDAHL NITROGEN (N) (MG/L)	TOTAL PHOSPHORUS (P) (MG/L)	DISSOLVED SOLIDS (SUM OF CONSTITUENTS) (MG/L)	TOTAL NONFILTRABLE RESIDUE (MG/L)	VOL. NONFILTRABLE RESIDUE (MG/L)	HARDNESS (CA,MG) (MG/L)
OCT.											
21...	--	.05	.01	.07	1.1	1.2	.18	191	43	15	56
MAR.											
20...	.3	.14	.01	.12	1.8	1.9	.37	45	952	200	29
MAY											
23...	.3	.10	.01	.01	1.4	1.4	.07	252	98	33	80
SEP.											
24...	--	.02	.01	.05	2.1	2.1	.19	296	69	33	87

DATE	NONCARBONATE HARDNESS (MG/L)	SODIUM ADSORPTION RATIO	SPECIFIC CONDUCTANCE (MICROMHOS)	PH (UNITS)	TEMPERATURE (DEG C)	COLOR (PLATINUM-COBALT UNITS)	TURBIDITY (JTU)	DISSOLVED OXYGEN (MG/L)	PERCENT SATURATION	BIOCHEMICAL OXYGEN DEMAND 5 DAY (MG/L)	TOTAL ORGANIC CARBON (C) (MG/L)
OCT.											
21...	0	2.5	352	6.1	22.0	80	30	11.2	127	1.6	13
MAR.											
20...	0	.8	112	5.9	19.5	240	150	8.7	94	4.5	19
MAY											
23...	3	3.1	490	7.8	29.5	140	75	8.5	110	2.4	9.3
SEP.											
24...	0	3.1	523	8.2	25.0	120	30	11.0	131	1.6	22

[illegible]

DATE	TIME	DIS-SOLVED ALUMI-NUM (AL) (UG/L)	DIS-SOLVED ARSENIC (AS) (UG/L)	DIS-SOLVED BARIUM (BA) (UG/L)	DIS-SOLVED CAD-MIUM (CD) (UG/L)	DIS-SOLVED CHRO-MIUM (CR) (UG/L)	DIS-SOLVED COBALT (CO) (UG/L)	DIS-SOLVED COPPER (CU) (UG/L)
JAN.								
22...	1120	100	1	240	0	0	0	6
APR.								
21...	1230	20	1	310	0	0	0	3
SEPT								
01...	[illegible]	[illegible]	3	[illegible]	0	0	0	3

DATE	DIS-SOLVED IRON (FE) (UG/L)	DIS-SOLVED LEAD (PB) (UG/L)	DIS-SOLVED LITHIUM (LI) (UG/L)	DIS-SOLVED MAN-GANESE (MN) (UG/L)	DIS-SOLVED MERCURY (HG) (UG/L)	DIS-SOLVED NICKEL (NI) (UG/L)	DIS-SOLVED STRON-TIUM (SR) (UG/L)	DIS-SOLVED ZINC (ZN) (UG/L)
JAN.								
22...	260	0	30	0	.1	0	210	20
APR.								
21...	40	0	30	0	.2	0	130	10
SEPT								
01...	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

DATE	TIME	INSTAN-TANEOUS DIS-CHARGE (CFS)	TEMPERA-TURE (DEG C)	TOTAL ALDRIN (UG/L)	TOTAL CHLOR-DANE (UG/L)	TOTAL DDD (UG/L)	TOTAL DDE (UG/L)	TOTAL DDT (UG/L)	TOTAL DI-AZINON (UG/L)
JAN.									
22...	1120	.42	11.0	.00	.0	.00	.00	.00	.00
APR.									
21...	1230	.60	26.5	.00	.0	.00	.00	.00	.00
SEP.									
01...	1100	2.3	27.0	.00	.0	.00	.00	.00	.00

DATE	TOTAL DI-ELDRIN (UG/L)	TOTAL ENDRIN (UG/L)	TOTAL ETHION (UG/L)	TOTAL HEPTA-CHLOR (UG/L)	TOTAL HEPTA-CHLOR EPOXIDE (UG/L)	TOTAL LINDANE (UG/L)	TOTAL MALA-THION (UG/L)	TOTAL METHYL PARA-THION (UG/L)	TOTAL METHYL THI-THION (UG/L)
JAN.									
22...	.00	.00	.00	.00	.00	.00	.00	.00	.00
APR.									
21...	.00	.00	.00	.00	.00	.00	.00	.00	.00
SEP.									
01...	.0	.00	.00	.00	.00	.00	.00	.00	.00

DATE	TOTAL PARA-THION (UG/L)	TOTAL PCB (UG/L)	POLY-CHLO-RINATED NAPH-THA-LENES (UG/L)	TOTAL TOX-APHENE (UG/L)	TOTAL THI-THION (UG/L)	TOTAL 2,4-D (UG/L)	TOTAL 2,4,5-T (UG/L)	TOTAL SILVEX (UG/L)
JAN.								
22...	.00	.0	--	0	.00	.00	.00	.00
APR.								
21...	.00	.0	.00	0	.00	.00	.00	.00
SEP.								
01...	.00	.0	.00	0	.00	.05	.01	.00

UNITED STATES DEPARTMENT OF THE INTERIOR - GEOLOGICAL SURVEY
ARKANSAS - CANEY CREEK NEAR CRYSTAL HILL

WATER QUALITY DATA, WATER YEAR OCTOBER 1977 TO SEPTEMBER 1978

DATE	TIME	INSTAN-TANEOUS DISCHARGE (CFS)	DIS-SOLVED SILICA (SIO2) (MG/L)	DIS-SOLVED CAL-CIUM (CA) (MG/L)	DIS-SOLVED MAG-NE-SIUM (MG) (MG/L)	DIS-SOLVED SODIUM (NA) (MG/L)	DIS-SOLVED POT-ASS-IUM (K) (MG/L)	BICAR-BONATE (HCO3) (MG/L)	CAR-BONATE (CO3) (MG/L)	DIS-SOLVED SULFATE (SO4) (MG/L)	DIS-SOLVED CHLO-RIDE (CL) (MG/L)
JAN.											
22...	1120	.93	7.8	20	3.6	140	10	122	0	40	160
APR.											
21...	1230	.60	6.4	14	2.9	120	7.0	113	0	13	150
SEP.											
01...	1100	2.3	20	22	4.0	32	5.0	192	0	16	51

DATE	DIS-SOLVED FLUO-RIDE (F) (MG/L)	TOTAL NITRATE (N) (MG/L)	TOTAL NITRITE (N) (MG/L)	TOTAL AMMONIA NITRO-GEN (N) (MG/L)	TOTAL ORGANIC NITRO-GEN (N) (MG/L)	TOTAL PHOS-PHORUS (P) (MG/L)	DIS-SOLVED SOLIDS (SUM OF CONSTI-TUENTS) (MG/L)	TOTAL NON-FILT-RABLE RESIDUE (MG/L)	VOL. NON-FILT-RABLE RESIDUE (MG/L)	HARD-NESS (CA,MG) (MG/L)	NON-CAR-BONATE HARD-NESS (MG/L)
JAN.											
22...	.5	.00	.01	.07	1.0	.25	443	176	66	65	0
APR.											
21...	.5	.00	.02	.09	1.3	.23	371	214	98	47	0
SEP.											
01...	.2	.01	.01	.22	1.9	.38	222	324	68	87	0

DATE	SODIUM AD-SORP-TION RATIO	SPE-CIFIC CON-DUCT-ANCE (MICRO-MHOS)	PH (UNITS)	TEMPER-ATURE (DEG C)	COLOR (PLAT-INUM-COBALT UNITS)	TUR-BID-ITY (JTU)	DIS-SOLVED OXYGEN (MG/L)	PER-CENT SATUR-ATION	BIO-CHEM-ICAL OXYGEN DEMAND 5 DAY (MG/L)	TOTAL ORGANIC CARBON (C) (MG/L)
JAN.										
22...	7.6	835	7.9	11.0	350	150	11.0	99	2.8	11
APR.										
21...	7.6	649	8.2	26.5	400	170	8.8	107	3.5	10
SEP.										
01...	1.8	392	6.7	27.0	160	100	6.5	82	5.4	8.4

ATTACHMENT E-1

CYPRESS CREEK DIURNAL FIELD MEASUREMENTS
FEBRUARY 11, 1976 CITY OF HOUSTON SURVEY

Station Location	Dissolved Oxygen (mg/l)		Temperature (°F)		Average pH	Average Conductivity (μmhos/cm)
	Range	Average	Range	Average		
Tettar Road	3.0-5.5	4.5	63-67	65	6.9	689
Aldine-Westfield Road	4.5-7.4	6.4	66-68	67	7.0	675
IH 45	6.0-7.8	6.9	67-70	69	6.9	714
Steubner-Airline Road	3.4-6.0	4.1	66-71	68	6.9	777
FM 149	3.3-6.4	4.3	66-74	69	6.9	792
US 290	3.8-5.8	4.7	67-73	70	8.0	5062

ATTACHMENT E-2

CYPRESS CREEK LABORATORY ANALYSES
FEBRUARY 11, 1976 CITY OF HOUSTON SURVEY

Station Location	BOD_5 (mg/l)	Org-N (mg/l)	NH_3 (mg/l)	NO_2 (mg/l)	NO_3 (mg/l)	Total P (mg/l)	Chloro a (mg/l)	TSS (mg/l)	TDS (mg/l)
Tettar Road	7	0.7	5.32	1.00	7.75	6.26	0	136	517
Aldine-Westfield Road	6	6.6	6.88	1.20	5.80	7.89	0	84	744
IH 45	>6	8.1	7.32	1.15	4.80	7.24	0	124	544
Steubner-Airline Road	7	8.6	9.60	0.50	2.55	7.60	0	85	564
FM 149	8	14.0	11.36	0.26	1.55	7.08	0	200	896
US 290	3	1.8	0.60	0.02	0.48	0	0	33	2,678

ATTACHMENT E-3

CYPRESS CREEK DIURNAL COLIFORM ANALYSES
FEBRUARY 11, 1976 CITY OF HOUSTON SURVEY

Station Location	Total Coliform (MPN/100 ml) Range	Total Coliform (MPN/100 ml) Log Average	Fecal Coliform (MPN/100 ml) Range	Fecal Coliform (MPN/100 ml) Log Average
Tettar Road	700- 1,700	1,157	50- 130	95
Aldine-Westfield Road	17,000-160,000	45,661	7,000- 92,000	28,248
IH 45	4,900- 7,900	5,935	80- 1,300	304
Steubner-Airline Road	50-≥240,000	------	<20-≥240,000	------
FM 149	<20- 92,000	2,725	<20- 790	223
US 290	<20- 7,900	821	<20- 310	109

ATTACHMENT F

EXISTING WASTE LOADS ON CYPRESS CREEK

			WCO No.	River[a] Mile	Flow[b] (MGD)	BOD_5[c] (mg/l)	NH_3[d] mg/l	BOD_5 (#/day)	L_o (#/day)	N_o (#/day)	Total (#/day)
A	Trunkline Gas Company		00960.01	28.2 (3.7)							
		Existing			No Discharge Permit		----	---	---	---	---
		Permitted			No Discharge Permit		----	---	---	---	---
B	Cypress Fairbanks ISD		10967.01	31.0 (0.8)							
		Existing			0.051	11.5	8.0	5	7	16	23
		Permitted			0.064	20.0	----	11	16	---	---
C	Harris Co. WCID #110		10792.01	9.8 (0.1)							
		Existing			Not yet constructed		----	---	---	---	---
		Permitted			0.300	20.0	----	50	75	---	---
D	WCID #116		10955.01	18.8							
		Existing			0.136	2.6	0.9	3	4	5	9
		Permitted			0.600	2.0	----	100	150	---	---
E	Memorial Hills UD		11044.01	6.7 (0.5)							
		Existing			0.102	9.4	8.0	8	12	31	43
		Permitted			0.210	20.0	----	35	53	---	---
F	Stonegate #5		11058.01	7.2 (0.8)							
		Existing			0.054	6.8	12.0	3	5	25	30
		Permitted			0.050	20.0	----	8	13	---	---
H	Ponderosa Central		11081.01	12.8							
		Existing			0.820	5.9	8.5	40	61	266	327
		Permitted			1.700	20.0	----	284	425	---	---
J	Lake Forest		11084.01	23.6							
		Existing			0.343	9.2	20.0	26	39	261	300
		Permitted			0.750	20.0	----	125	188	---	---

			WCC No.	Acres/Mile	[illegible]	BOD_5 (mg/l)	NH_3 (mg/l)	BOD_5 (#/day)	L_o (#/day)	N_o (#/day)	Total (#/day)
K	Tomball Road UD		11089.01	22.4							
		Existing			0.213	13.9	7.1	25	37	57	95
		Permitted			0.300	20.0	----	50	75	---	---
L	Bammel Central		11105.01	17.4 (1.[illegible])							
		Existing			0.239	2.9	1.9	6	9	17	26
		Permitted			1.000	20.0	----	167	250	---	---
M	Haude Elementary		11129.01	11.0 (1.7)							
		Existing			0.009	7.3	8.0	1	1	3	4
		Permitted			0.019	20.0	----	3	5	---	---
N	Treschwig		11141.01	4.3							
		Existing			0.295	4.9	7.2	12	18	81	99
		Permitted			0.865	20.0	----	144	216	---	---
P	Timberlane		11142.01	[illegible]							
		Existing			0.151	11.1	8.7	14	21	50	71
		Permitted			0.300	20.0	----	50	75	---	---
Q	Spring Creek Forest PUD		11192.01	16.0 (2.4)							
		Existing			0.033	10.0	12.0	3	4	15	19
		Permitted			0.050	20.0	----	8	13	---	---
R	Dove Meadows MUD		11215.01	11.0 (4.3)							
		Existing			0.051	[illegible]	12.0	4	6	23	29
		Permitted			0.140	20.0	----	23	35	---	---
S	Harris County WCID #110 Interim		11239.02	9.8 (0.1)							
		Existing			0.136	2.6	11.3	3	4	59	63
		Permitted			0.100	20.0	----	17	25	---	---
T	CNP Utility District		11239.03	10.4							
		Existing			0.018	25.0	8.0	4	6	5	11
		Permitted			0.100	20.0	----	17	25	---	---

			WCD No.	River[a] Mile	Flow[b] (MGD)	BOD_5[c] mg/l	NH_3[d] mg/l	BOD_5 (#/day)	L_o (#/day)	N_o (#/day)	Total (#/day)
U	Timberlake ID		11267.01	29.6							
		Existing			0.058	2.4	[illegible]	1	7	2	4
		Permitted			[illegible].300	20.0	----	[illegible]	[illegible]	---	---
V	Candlelight Hills		11214.01	11.9							
		Existing			0.040	5.7	12.0	2	3	18	21
		Permitted			0.050	20.0	----	8	13	---	---
X	Ly-Champ PUD		11382.01	20.0							
		Existing			Not Yet Constructed.			---	---	---	---
		Permitted			[illegible].100	20.0	----	17	25	---	---
Y	Cypress-Klein MD		11366.01	16.[illegible]							
		Existing		[illegible]	0.043	17.3	[illegible]	6	9	20	29
		Permitted			[illegible].100	20.0	----	17	25	---	---
Z	Kleinwood Central		11409.01	12.1							
		Existing			[illegible]	4.2	[illegible]	12	18	31	49
		Permitted			1.000	20.0	----	167	250	---	---
AA	Charterwood MUD		11410.01	22.7							
		Existing		(1.7)	0.009	2.0	[illegible].0	[illegible]	1	1	1
		Permitted			0.120	10.0	----	10	15	---	---
BB	Harris Co. WCID #99		11333.01	6.8							
		Existing			[illegible].108	2.4	3.2	2	3	13	16
		Permitted			0.225	20.0	----	38	56	---	---
CC	Cypress-Fairbanks Matzke		11454.01	24.7							
		Existing		(1.2)	0.025	7.0	8.0	1	2	8	10
		Permitted			0.050	20.0	----	8	13	---	---
DD	Harris Co. MUD #29		11527.01	23.0							
		Existing		(1.9)	Not Yet Constructed.			---	---	---	---
		Permitted			0.200	20.0	----	33	50	---	---

Reproduced from best available copy.

			WCC No.	River[a] Mile	Flow[b] (MGD)	BOD_5[b] (mg/l)	NH_3[c] (mg/l)	BOD_5 (#/day)	L_o (#/day)	N_o (#/day)	Total (#/day)
EE	Northland Industrial Park		11[illegible]	[illegible]							
		Existing		[illegible]	0.014	2.6	8.0	<1	<1	4	5
		Permitted			0.021	20.0	----	4	5	---	---
FF	Harris County MUD #14		11615.01	[illegible]							
		Existing		[illegible]	0.007	4.2	[illegible]	<1	<1	2	2
		Permitted			0.100	20.0	----	17	25	---	---
GG	Spring North Park		11656.01	8.8							
		Existing			Not yet constructed			---	---	---	---
		Permitted			[illegible]	10.0	[illegible]	58	58	133	221
HH	Harris County MUD #82		10518.[illegible]	19.[illegible]							
		Existing			0.317	5.6	[illegible]	15	22	216	238
		Permitted			0.320	16.0	----	43	64	---	---
JJ	Harris County WCID #91		[illegible]	11.6							
		Existing		[illegible]	0.059	11.3	13.6	34	51	172	223
		Permitted			0.320	20.0	----	63	80	---	---
KK	Harris County WCID #113		[illegible]	30.4							
		Existing			0.032	7.1	11.4	5	7	36	43
		Permitted			0.150	20.0	----	25	38	---	---
LL	Harris County WCID #119		[illegible]	18.5							
		Existing		2.6	0.107	3.6	3.0	3	5	12	17
		Permitted			0.700	20.0	----	117	175	---	---
MM	Inverness Forest ID		[illegible]	[illegible]							
		Existing			0.167	8.5	6.5	12	19	41	59
		Permitted			[illegible]	20.0	----	67	100	---	---
NN	City of Waller		10317.01	52.4							
		Existing		9.3	0.101	20.1	6.0	17	25	31	56
		Permitted			0.200	20.0	----	33	50	---	---

			WCC No.	River[a] Mile	Flow[b] (MGD)	BOD_5[b] (mg/l)	NH_3[c] (mg/l)	BOD_5 (#/day)	L_D (#/day)	N_D (#/day)	Total (#/day)
PP	Waller County WCID #2		11639.01	53.3							
		Existing		(4.6)	Not Yet Constructed.			---	---	---	---
		Permitted			0.100	20.0	----	17	25	---	---
RR	Plains Machinery Co.		11755.01	3.2							
		Existing		(1.0)	Began Operation October 1976.			---	---	---	---
		Permitted			0.003	10.0	5.0	1	1	1	1

[a] Parentheses indicate river mile up the tributary.

[b] Based on average TWQB self-reporting data from January 1976-September 1976.

[c] Based on return flow data and field measurements.

ATTACHMENT G

CYPRESS CREEK WASTE LOADS
FEBRUARY 11, 1976

	Flow (cfs)	BOD_5 (mg/l)	BOD_u (mg/l)	Org-N (mg/l)	NH_3 (mg/l)	NO_2 (mg/l)	NO_3 (mg/l)	TSS (mg/l)	Total P (mg/l)	Total Coliform (MPN/100 ml)	Fecal Coliform (MPN/100 ml)
Cypress Fairbanks ISD	0.080	7.0	10.5	9.0	8.0	0.1	4.0	--	----	-------	-------
Harris County WCID #110	0										
WCID #116	0.189	5.0	7.5	2.6	0.9	0.1	0.5	2	13.0	19,387	7,575
Memorial Hills UD	0.142	6.0	9.0	9.0	8.0	0.1	4.0	--	----	-------	-------
Stonegate #5	0.087	6.0	9.0	14.0	12.0	0.1	1.0	--	----	-------	-------
Ponderosa Central	1.060	5.0	7.5	9.6	8.5	0.1	3.6	1	12.4	<20	<20
Lake Forest	0.493	10.0	15.0	22.0	20.0	0.1	1.0	--	----	-------	-------
Tomball Road UD	0.357	5.0	7.5	8.0	7.1	0.2	1.1	--	----	-------	-------
Bammel Central	0.370	3.0	4.5	1.5	1.9	0.2	25.8	2	14.4	278	125
Haude Elementary	0.014	4.0	6.0	9.0	8.0	0.1	4.0	--	----	-------	-------
Treschwig	0.292	5.0	7.5	8.3	7.2	0.1	0.1	4	12.3	77	20
Timberlane	0.200	6.0	9.0	10.0	8.7	0.1	6.4	--	----	-------	-------
Spring Creek Forest PUD	0.050	24.0	36.0	14.0	12.0	0.1	1.0	--	----	-------	-------
Dove Meadows MUD	0.037	26.0	39.0	14.0	12.0	0.1	1.0	--	----	-------	-------
Harris Co. WCID #110 Interim	0.334	33.3	50.0	7.2	11.3	3.8	2.8	68	3.8	364	38
CNP Utility District	0										
Timberlake ID	0.073	3.0	4.5	0.7	0.0	0.1	23.9	2	12.0	<20	<20

	Flow (cfs)	BOD_5 (mg/l)	BOD_u (mg/l)	Org-N (mg/l)	NH_3 (mg/l)	NO_2 (mg/l)	NO_3 (mg/l)	TSS (mg/l)	Total P (mg/l)	Total Coliform (MPN/100 ml)	Fecal Coliform (MPN/100 ml)
Candlelight Hills	0.057	9.0	13.5	14.0	12.0	0.1	1.0	--	----	-------	-------
Cy-Champ PUD	0										
Cypress-Klein UD	0.050	22.0	33.0	14.0	12.0	0.1	1.0	--	----	-------	-------
Kleinwood Central	0.429	4.0	6.0	1.3	2.4	0.0	7.3	4	10.8	58	20
Charterwood MUD	0.008	1.0	1.5	1.0	2.0	0.1	10.0	--	----	-------	-------
Harris Co. WCID #99	0.159	6.0	9.0	4.2	3.2	0.0	25.3	17	12.0	96	41
Cypress-Fairbanks Matzke	0.039	2.0	3.0	9.0	8.0	0.1	4.0	--	----	-------	-------
Harris Co. MUD #29	0										
Northland Shopping Center	0.022	2.0	3.0	9.0	8.0	0.1	4.0	--	----	-------	-------
Harris Co. MUD #24	0										
Spring North Park	0										
Harris Co. FWSD #52	0.464	13.3	20.0	15.8	17.9	0.1	0.2	4	8.0	20	20
Harris Co. WCID #91	0.545	14.0	21.0	14.1	12.6	0.2	0.2	26	9.6	717	278
Harris Co. WCID #113	0.091	4.0	6.0	14.0	11.4	1.1	5.1	--	----	-------	-------
Harris Co. WCID #119	0.133	7.0	10.5	2.5	3.0	0.4	15.0	14	12.7	>240,000	160,000
Inverness Forest ID	0.260	5.0	7.5	8.0	6.5	4.8	5.4	--	----	-------	-------
City of Waller	0.139	13.0	19.5	----	----	---	----	--	----	-------	-------
Waller County WCID #2	0										
Plains Machinery Co.	0										

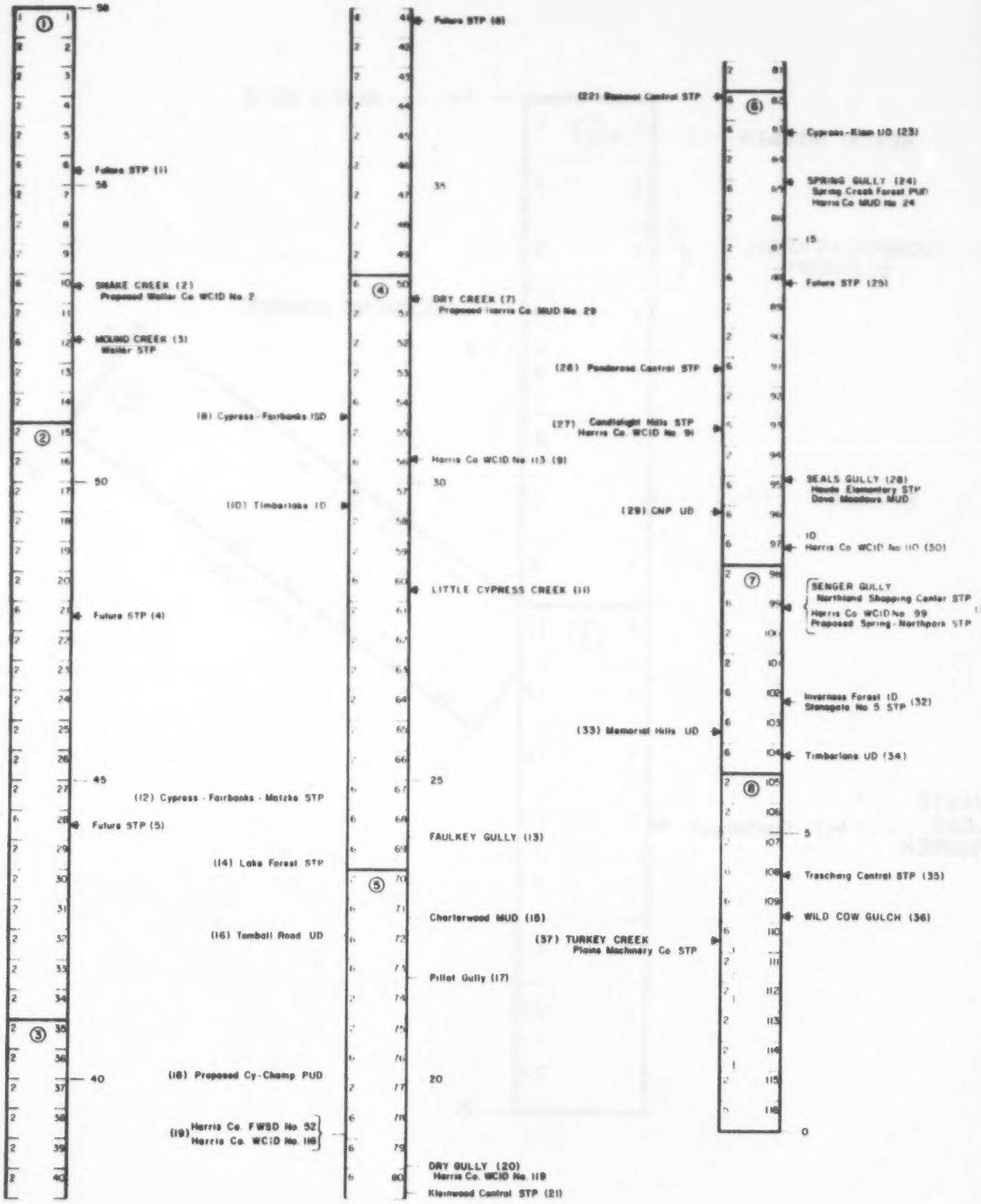
ATTACHMENT H

CYPRESS CREEK HYDRAULIC MEASUREMENTS

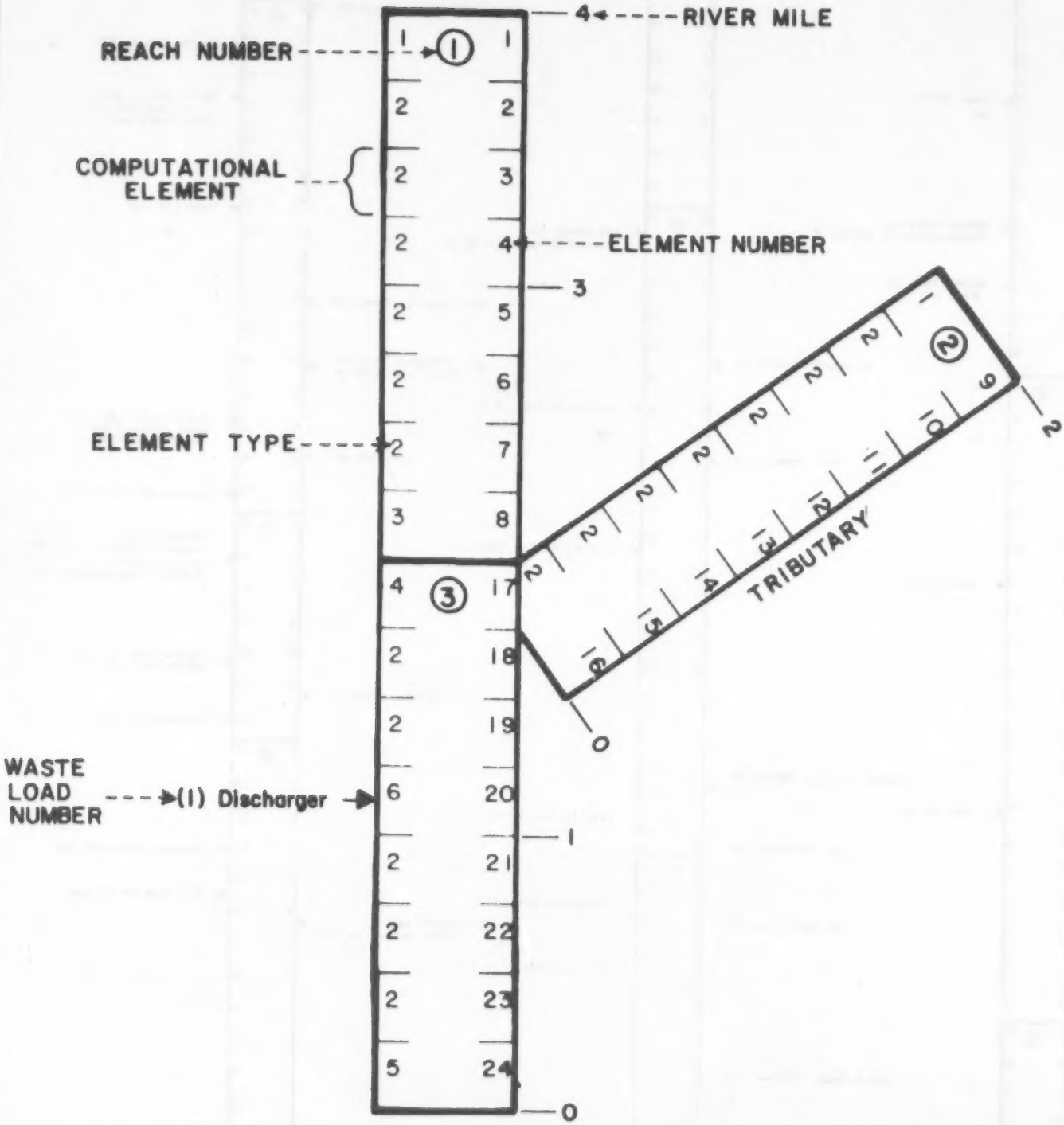
Station Location	USGS Station Average Daily Flow (cfs)	Dye Study Instantaneous Flows (cfs)	Dye Study Velocity (fps)
Sharp Road	0.09		
Katy-Hockley Road	0		
House-Hahl Road	0.04		
Grant Road		0.48	0.08
FM 149		0.48	
Steubner-Airline Road		2.24	0.19
Kuykendahl Road		3.06	
IH 45	6.20	4.44	0.25
Hardy Road		5.19	

ATTACHMENT J-I

CYPRESS CREEK SCHEMATIC



ATTACHMENT J-2
SCHEMATIC EXPLANATION



ATTACHMENT K

CYPRESS CREEK
QUAL-II MODEL INPUT

```
$$$ (PROBLEM TITLES) $$$

CARD TYPE
TITLE1                    QUAL-II PROGRAM TITLES
TITLE2                    INTERNET EXPANDED VERSION OF QUAL-I
TITLE3    NO              NAME OF BASIN :CYPRESS CREEK SEGMENT 1000          RUN 839
TITLE4    NO              CONSERVATIVE MINERAL  I  IN MG/L
TITLE5    NO              CONSERVATIVE MINERAL  II  IN MG/L
TITLE6    NO              CONSERVATIVE MINERAL III  IN MG/L
TITLE7    YES             TEMPERATURE IN DEGREES FAHRENHEIT
TITLE8    NO              BIOCHEMICAL OXYGEN DEMAND IN MG/L
TITLE9    NO              ALGAE AS CHL A IN UG/L
TITLE10   NO              PHOSPHORUS AS P IN MG/L
TITLE11   YES             ORGANIC NITROGEN AS N IN MG/L
TITLE12   YES             AMMONIA AS N IN MG/L
TITLE13   YES             NITRITE AS N IN MG/L
TITLE14   YES             NITRATE AS N IN MG/L
TITLE15   YES             DISSOLVED OXYGEN IN MG/L
TITLE16   NO              COLIFORMS AS MPN
TITLE17   NO              FLUORIDE
ENDTITLE
```

Reproduced from best available copy.

```
$$$ DATA TYPE 1 (CONTROL DATA) $$$

CARD TYPE                                          CARD TYPE
LIST DATA INPUT              .00000
WRITE FINAL SUMMARY          .00000                                  .00000
NO FLOW AUGMENTATION         .00000                                  .00000
STEADY STATE SIMULATION      .00000                                  .00000
NUMBER OF REACHES            8.00000                                 .00000
NUM OF HEADWATERS            1.000 0   NUMBER OF JUNCTIONS      :   .00000
TIME STEP (HOURS)            .00000    NUMBER OF WASTELOADS     :  17.00000
MAXIMUM ROUTE TIME (HRS)     30.00000  LNTH. COMP ELEMENT (MI)  :   .50000
LATITUDE OF BASIN (DEG)      .00000    TIME INC. FOR RPT2 (HRS) :  30.00000
STANDARD MERIDIAN (DEG)      .00000    LONGITUDE OF BASIN (DEG) :   .00000
EVAP. COEFF.,(BE)            .00000    DAY OF YEAR START TIME   :   .00000
ELEVATION OF BASIN           .00000    EVAP. COEFF.,(BE)        :   .00000
ENDATA1                      .00000    DUST ATTENUATION COEF.   :   .00000
                                                                    .00000

$$$DATA TYPE 1A (ALGAE PRODUCTION AND NITROGEN OXIDATION CONSTANTS)$$$

CARD TYPE                                          CARD TYPE
O UPTAKE BY ORG N (MG O/MG N)  :   .0000
O UPTAKE BY NH3 OXIDING O/MG N):  3.4300                                .0000
O PROD. BY ALGAE (MG O/MG A)   :  1.6000   O UPTAKE BY NO2 OXIDING O/MG N):  1.1400
N CONTENT OF ALGAE (MG N/MG A) :   .0850   O UPTAKE BY ALGAE (MG O/MG A)  :  1.9500
ALG MAX SPEC GROWTH RATE(1/DAY):  2.0000   P CONTENT OF ALGAE (MG P/MG A) :   .0130
N HALF SATURATION CONST. (MG/L):   .3000   ALGAE RESPIRATION RATE (1/DAY) :   .1000
LIGHT HALF SAT CONST(LNGLY/MIN):   .0300   P HALF SATURATION CONST. (MG/L):   .0400
ENDATA1A                           .0000   TOTAL DAILY RADIATION(LANGLEYS):300.0000
                                                                            .0000

$$$ DATA TYPE 2 (REACH IDENTIFICATION) $$$

CARD TYPE          REACH ORDER AND IDENT                  R. MILE              R. MILE
STREAM REACH    1.  RCH=WALLER                  FROM     58.0    TO     51.0
STREAM REACH    2.  RCH=WALLER KTY-HCKLY        FROM     51.0    TO     41.0
STREAM REACH    3.  RCH=KTY-HCKLY US 290        FROM     41.0    TO     33.5
STREAM REACH    4.  RCH=US 290 FM 149           FROM     33.5    TO     23.5
STREAM REACH    5.  RCH=FM149 STEUB-AIRL        FROM     23.5    TO     17.5
STREAM REACH    6.  RCH=STEUB-AIRL IH 45        FROM     17.5    TO      9.5
STREAM REACH    7.  RCH=IH45 ALD-WESTFLD        FROM      9.5    TO      6.0
STREAM REACH    8.  RCH=ALD-WEST TETTAR         FROM      6.0    TO       .0
ENDATA2         0.                                         .0             .0

$$$ DATA TYPE 3 (TARGET LEVEL DO AND FLOW AUGMENTATION SOURCES) $$$

CARD TYPE          REACH  AVAIL MGWS TARGET      ORDER OF AVAIL SOURCES
FLOW AUGMT SOURCES  1.      0.        .0   0.    0.    0.    0.    0.    0.
FLOW AUGMT SOURCES  2.      0.        .0   0.    0.    0.    0.    0.    0.
FLOW AUGMT SOURCES  3.      0.        .0   0.    0.    0.    0.    0.    0.
FLOW AUGMT SOURCES  4.      0.        .0   0.    0.    0.    0.    0.    0.
FLOW AUGMT SOURCES  5.      0.        .0   0.    0.    0.    0.    0.    0.
FLOW AUGMT SOURCES  6.      0.        .0   0.    0.    0.    0.    0.    0.
FLOW AUGMT SOURCES  7.      0.        .0   0.    0.    0.    0.    0.    0.
FLOW AUGMT SOURCES  8.      0.        .0   0.    0.    0.    0.    0.    0.
ENDATA3             0.      0.        .0   0.    0.    0.    0.    0.    0.
```

Reproduced from
best available copy.

```
$$$ DATA TYPE 4 (COMPUTATIONAL REACH FLAG FIELDS) $$$

CARD TYPE          REACH ELEMENTS/REACH          COMPUTATIONAL FLAGS
FLAG FIELD          1.        10.          1.....2....3.4.5.6....7.**********
FLAG FIELD          2.        20.          2.....2.2.2.2.2.4.5.2.2.2.2.2.2.
FLAG FIELD          3.        15.          3.....2.2.4.2.2.2.2.2.....2.**********
FLAG FIELD          4.        10.          4.....4.4.4.4.4.4.4.4.4.4.4.4.4.4.
FLAG FIELD          5.        12.          5.4.4.4.4.4.4.4.4.4.4.4.4.4.**********
FLAG FIELD          6.        10.          6.4.2.4.4.4.4.4.2.2.4.4.4.4.4.4.********
FLAG FIELD          7.         7.          7.4.4.....4.4.4.**********************
FLAG FIELD          8.        12.          .....4.4.4.4.2.....2.2.2.4.**********
ENDATA              0.         0.          ****************************************

$$$ DATA TYPE 5 (HYDRAULIC COEFFICIENTS FOR DETERMINING VELOCITY AND DEPTH) $$$

CARD TYPE          REACH              COEFQV     EXPQQV     COEFDH     EXPDDH     CMANN
HYDRAULICS          1.          .1150000      .500       1.800      .500       .035
HYDRAULICS          2.          .1150000      .500       1.800      .500       .035
HYDRAULICS          3.          .1150000      .500       1.800      .500       .035
HYDRAULICS          4.          .1150000      .500       1.800      .500       .035
HYDRAULICS          5.          .1150000      .500       1.800      .500       .035
HYDRAULICS          6.          .1150000      .500       .600       .500       .035
HYDRAULICS          7.          .1150000      .500       .600       .500       .035
HYDRAULICS          8.          .0500000      .500       .800       .500       .035
ENDDATA             0.          .0000000      .000       .000       .000       .000

$$$ DATA TYPE 6 (REACTION COEFFICIENTS FOR DEOXYGENATION AND REAERATION) $$$

CARD TYPE          REACH      K1         K3         K4,OPT     K2         LOEFOR2    EXPOR2
REACT COEF          1.        .10        .04        1.         .00        .100       .000
REACT COEF          2.        .10        .10        1.         .00        .100       .000
REACT COEF          3.        .10        .00        1.         .00        .100       .000
REACT COEF          4.        .10        .10        1.         .00        .100       .000
REACT COEF          5.        .10        .00        1.         .00        .100       .000
REACT COEF          6.        .10        .06        1.         .00        .100       .000
REACT COEF          7.        .10        .00        1.         .00        .100       .000
REACT COEF          8.        .10        .10        1.         .00        .100       .000
ENDATA              0.        .00        .00        0.         .00        .100       .000

$$$ DATA TYPE 10 (ALGAE, NITROGEN, AND PHOSPHORUS CONSTANTS) $$$

CARD TYPE                  REACH  ALGAN  ALGSET  CRNH4  CRNO2  SNH4   SPO4   ORG-N
ALGAE, N AND P COEF         1.    25.0    .00    .00    .00    .00    .00    .00
ALGAE, N AND P COEF         2.    25.0    .00    .06    .00    .00    .00    .00
ALGAE, N AND P COEF         3.    25.0    .00    .06    .00    .00    .00    .00
ALGAE, N AND P COEF         4.    25.0    .00    .10    1.50   .00    .00    .07
ALGAE, N AND P COEF         5.    25.0    .00    .10    1.50   .00    .00    .07
ALGAE, N AND P COEF         6.    25.0    .00    .15    1.50   .00    .00    .10
ALGAE, N AND P COEF         7.    25.0    .00    .15    1.50   .00    .00    .10
ALGAE, N AND P COEF         8.    25.0    .00    .20    1.50   .00    .00    .15
ENDATA0A                    0.     .0     .00    .00    .00    .00    .00    .00

$$$ DATA TYPE 20 (OTHER COEFFICIENTS) $$$

CARD TYPE                  REACH    CRN       CRS       FACOEF    CRB
OTHER COEFFICIENTS          1.      .00       .00       .10       .06
OTHER COEFFICIENTS          2.      .00       .00       .10       .00
OTHER COEFFICIENTS          3.      .00       .00       .10       .00
OTHER COEFFICIENTS          4.    [illegible]  .00      .10       .00
OTHER COEFFICIENTS          5.    1000.00     .00       .10       .00
OTHER COEFFICIENTS          6.    1500.00     .00       .10       .00
OTHER COEFFICIENTS          7.    2500.00     .00       .10       .00
OTHER COEFFICIENTS          8.    3500.00     .00       .10       .06
ENDATA0B                    0.     .00        .00       .00       .06

$$$ DATA TYPE 7 (INITIAL CONDITIONS) $$$

CARD TYPE                  REACH    TEMP   D.O.  PHP     CM-I      CM-II     CM-III
INITIAL CONDITIONS          1.     70.0    .0    .0      .0        .0        .0
INITIAL CONDITIONS          2.     70.0    .0    .0      .0        .0        .0
INITIAL CONDITIONS          3.     70.0    .0    .0      .0        .0        .0
INITIAL CONDITIONS          4.     69.9    .0    .0      .0        .0        .0
INITIAL CONDITIONS          5.     68.5    .0    .0      .0        .0        .0
INITIAL CONDITIONS          6.     68.6    .0    .0      .0        .0        .0
INITIAL CONDITIONS          7.     68.2    .0    .0      .0        .0        .0
INITIAL CONDITIONS          8.     66.9    .0    .0      .0        .0        .0
ENDATA7                     0.      .0     .0    .0      .0        .0        .0

$$$ DATA TYPE 7A (INITIAL CONDITIONS FOR CHLOROPHYLL A, NITROGEN, PHOSPHORUS,
                  COLIFORM AND RADIONUCLIDE) $$$

CARD TYPE                  REACH CHLORA  NH3   NO2   NO3   PO4   COLI    RADN      ORG-N
INITIAL COND-2              1.     .0    .00   .00   .00   .00          .0        .00   .00
INITIAL COND-2              2.     .0    .00   .00   .00   .00          .0        .00   .00
INITIAL COND-2              3.     .0    .00   .00   .00   .00          .0        .00   .00
INITIAL COND-2              4.     .0    .00   .00   .00   .00          .0        .00   .00
INITIAL COND-2              5.     .0    .00   .00   .00   .00          .0        .00   .00
INITIAL COND-2              6.     .0    .00   .00   .00   .00          .0        .00   .00
INITIAL COND-2              7.     .0    .00   .00   .00   .00          .0        .00   .00
INITIAL COND-2              8.     .0    .00   .00   .00   .00          .0        .00   .00
ENDATA7A                    0.     .0    .00   .00   .00   .00          .0        .00   .00
```

$$$ DATA TYPE 8 (RUNOFF CONDITIONS) $$$

CARD TYPE	REACH NO.	TEMP	D.O.	BOD	CM-I	CM-II	CM-III
RUNOFF CONDITIONS	1.	.0	.0	.0	.0	.0	.0
RUNOFF CONDITIONS	2.	.0	.0	.0	.0	.0	.0
RUNOFF CONDITIONS	3.	.0	.0	.0	.0	.0	.0
RUNOFF CONDITIONS	4.	.0	.0	.0	.0	.0	.0
RUNOFF CONDITIONS	5.	.0	.0	.0	.0	.0	.0
RUNOFF CONDITIONS	6.	.0	.0	.0	.0	.0	.0
RUNOFF CONDITIONS	7.	.0	.0	.0	.0	.0	.0
RUNOFF CONDITIONS	8.	.0	.0	.0	.0	.0	.0
ENDATA8	0.	.0	.0	.0	.0	.0	.0

$$$ DATA TYPE 8A (INCREMENTAL FLOW CONDITIONS FOR NITROGEN,PHOSPHOROUS,
COLIFORM AND RADIONUCLIDE) $$$

CARD TYPE	REACH	CHLORA	NH3	NO2	NO3	PO4	COLI	RADN	ORG-N
RUNOFF COND-2	1.	.0	.00	.00	.00	.00	.0	.00	.00
RUNOFF COND-2	2.	.0	.00	.00	.00	.00	.0	.00	.00
RUNOFF COND-2	3.	.0	.00	.00	.00	.00	.0	.00	.00
RUNOFF COND-2	4.	.0	.00	.00	.00	.00	.0	.00	.00
RUNOFF COND-2	5.	.0	.00	.00	.00	.00	.0	.00	.00
RUNOFF COND-2	6.	.0	.00	.00	.00	.00	.0	.00	.00
RUNOFF COND-2	7.	.0	.00	.00	.00	.00	.0	.00	.00
RUNOFF COND-2	8.	.0	.00	.00	.00	.00	.0	.00	.00
ENDATA8A	0.	.0	.00	.00	.00	.00	.0	.00	.00

$$$ DATA TYPE 9 (STREAM JUNCTIONS) $$$

CARD TYPE	JUNCTION ORDER AND IDENT	UPSTRM	JUNCTION	TRIB
ENDATA9	0.	0.	0.	0.

$$$ DATA TYPE 10 (HEADWATER SOURCES) $$$

CARD TYPE	HDWATER ORDER AND IDENT	FLOW	TEMP	D.O.	BOD	CM-I	CM-II	CM-III
HEADWATER	1. HWG-CYPRESS HEADWTR	.1	20.0	4.7	4.5	.0	.0	.0
ENDATA10	0.	.0	.0	.0	.0	.0	.0	.0

$$$ DATA TYPE 10A (HEADWATER CONDITIONS FOR CHLOROPHYLL,NITROGEN, PHOSPHOROUS,
COLIFORM AND RADIONUCLIDE) $$$

CARD TYPE	HDWATER	CHLORA	NH3	NO2	NO3	PO4	COLI	RADN	ORG-N
HEADWATER-2	1.	.0	.60	.02	.48	.00	.0	.00	1.80
ENDATA10A	0.	.0	.00	.00	.00	.00	.0	.00	.00

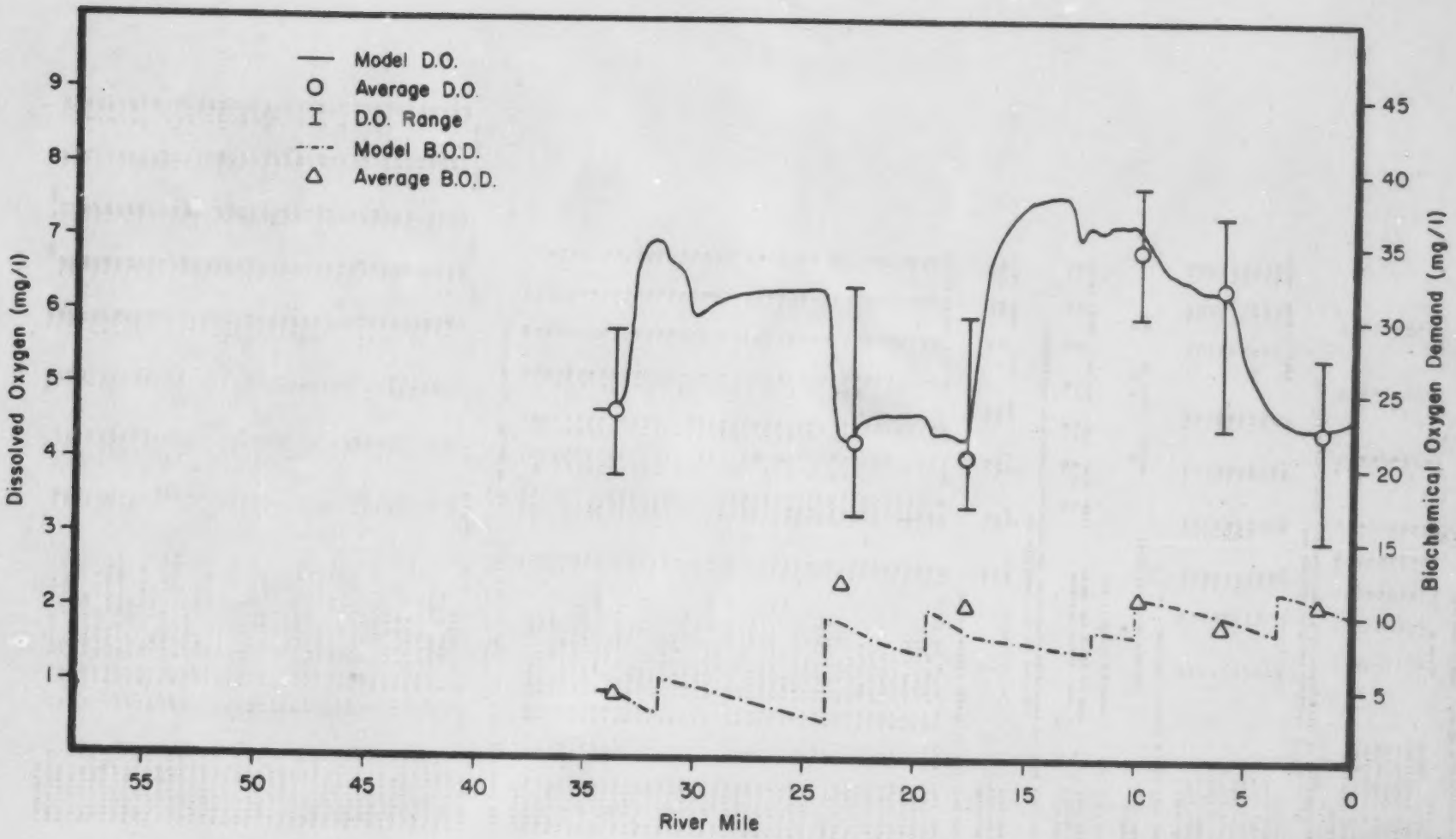
$$$ DATA TYPE 11 (WASTE LOADINGS) $$$

CARD TYPE	WASTE LOAD ORDER AND IDENT	EFF	FLOW	TEMP	D.O.	BOD	CM-I	CM-II	CM-III
WASTELOAD	1. WSL FUTURE01	.00	.0000	.0	.0	.0	.0	.0	.0
WASTELOAD	2. WSL SNAKE CREEK	.00	.0000	.0	.0	.0	.0	.0	.0
WASTELOAD	3. WSL MOUND CREEK	.00	.0000	.0	.0	.0	.0	.0	.0
WASTELOAD	4. WSL FUTURE04	.00	.0000	.0	.0	.0	.0	.0	.0
WASTELOAD	5. WSL FUTURE05	.00	.0000	.0	.0	.0	.0	.0	.0
WASTELOAD	6. WSL FUTURE06	.00	.0000	.0	.0	.0	.0	.0	.0
WASTELOAD	7. WSL DRY CREEK	.00	.0000	.0	.0	.0	.0	.0	.0
WASTELOAD	8. WSL CY-FAIR ISD	.00	.0800	26.0	6.0	9.0	.0	.0	.0
WASTELOAD	9. WSL HC WCID 111	.00	.0910	26.0	4.0	6.0	.0	.0	.0
WASTELOAD	10. WSL TIMBERLANE II	.00	.0730	20.0	4.0	4.5	.0	.0	.0
WASTELOAD	11. WSL LITTLE CYPRESS	.00	.0060	.0	.0	.0	.0	.0	.0
WASTELOAD	12. WSL CY-FAIR MAT,HI	.00	.0390	20.0	6.0	2.2	.0	.0	.0
WASTELOAD	13. WSL FAULKEY GULLY	.00	.0000	.0	.0	.0	.0	.0	.0
WASTELOAD	14. WSL CARL FOREST STP	.00	.4930	26.0	4.0	17.0	.0	.0	.0
WASTELOAD	15. WSL CHARTERWOOD MUD	.00	.0080	20.0	4.0	1.0	.0	.0	.0
WASTELOAD	16. WSL TOMBALL HI SCH	.00	.1870	20.0	4.0	7.5	.0	.0	.0
WASTELOAD	17. WSL PILLOT GULLY	.00	.0060	.0	.0	.0	.0	.0	.0
WASTELOAD	18. WSL CY CHAMP PUD	.00	.0000	.0	.0	.0	.0	.0	.0
WASTELOAD	19. WSL HARRIS CO. WCID 116	.00	.6530	26.0	4.0	17.4	.0	.0	.0
WASTELOAD	20. WSL DRY GULLY	.00	.1330	20.0	6.0	7.1	.0	.0	.0
WASTELOAD	21. WSL [illegible] CENTRE	.00	.4290	20.0	4.0	6.6	.0	.0	.0
WASTELOAD	22. WSL [illegible] CENTRE	.00	.3700	21.0	6.0	4.9	.0	.0	.0
WASTELOAD	23. WSL CYPRESS HILL IN UD	.00	.0560	20.0	6.0	27.7	.0	.0	.0
WASTELOAD	24. WSL SPRING GULLY	.00	.1300	20.1	6.0	20.5	.0	.0	.0
WASTELOAD	25. WSL FUTURE25	.00	.0000	.0	.0	.0	.0	.0	.1
WASTELOAD	26. WSL PONDEROSA WSTADR	.00	1.6600	27.0	4.0	7.5	.0	.0	.0
WASTELOAD	27. WSL CANDLELITE WCID 91	.00	.6000	23.0	6.0	17.1	.0	.0	.0
WASTELOAD	28. WSL SEALY GULLY	.00	.0910	20.0	6.0	9.7	.0	.0	.0
WASTELOAD	29. WSL CHP OF INTERIM	.00	.0000	.0	.0	.0	.0	.0	.0
WASTELOAD	30. WSL WCID 0110	.00	.3340	72.0	4.0	51.0	.0	.0	.0
WASTELOAD	31. WSL NED WCID99-SPNPR	.00	.1810	67.9	4.0	4.0	.0	.0	.0
WASTELOAD	32. WSL STONE-INVERNESS	.00	.3970	20.0	5.0	7.6	.0	.0	.0
WASTELOAD	33. WSL MEMORIAL HILLS	.00	.1420	20.0	6.0	9.4	.0	.0	.0
WASTELOAD	34. WSL TIMBERLANE	.00	.2000	20.0	6.0	7.6	.0	.0	.0
WASTELOAD	35. WSL THESCHOIS (01361)	.00	.0920	20.0	4.0	7.5	.0	.0	.0
WASTELOAD	36. WSL WILD CAT GULCH	.00	.0000	.0	.0	.0	.0	.0	.0
WASTELOAD	37. WSL TURKEY CREEK	.00	1.0000	20.0	4.0	30.0	.0	.0	.0
ENDATA11	1.	.00	.0000	.0	.0	.0	.0	.0	.0

$$$ DATA TYPE 11A (WASTE LOAD CHARACTERISTICS - ALGAE,NITROGEN,PHOSPHOROUS,
COLIFORMS AND RADIONUCLIDES) $$$

CARD TYPE	WASTE LOAD ORDER AND IDENT	CHL A	NH3	NO2	NO3	PO4	COLI	RADN	ORG-N
WASTELOAD-2	1. WSL FUTURE01	.00	.00	.00	.00	.00	.00	.00	.00
WASTELOAD-2	2. WSL SNAKE CREEK	.00	.00	.00	.00	.00	.00	.06	.00
WASTELOAD-2	3. WSL MOUND CREEK	.00	.00	.00	.00	.00	.00	.00	.00
WASTELOAD-2	4. WSL FUTURE04	.00	.00	.00	.00	.00	.00	.00	.00
WASTELOAD-2	5. WSL FUTURE05	.00	.00	.00	.00	.00	.00	.00	.00
WASTELOAD-2	6. WSL FUTURE06	.00	.00	.00	.00	.00	.00	.00	.00
WASTELOAD-2	7. WSL DRY CREEK	.00	.00	.00	.00	.00	.00	.00	.00
WASTELOAD-2	8. WSL CY-FAIR ISD	.00	6.90	.10	5.00	.00	.00	.00	7.70
WASTELOAD-2	9. WSL HC WCID 111	.00	11.40	1.09	5.11	.00	.00	.00	16.00
WASTELOAD-2	10. WSL TIMBERLANE II	.00	.00	.10	23.90	.00	.00	.00	.70
WASTELOAD-2	11. WSL LITTLE CYPRESS	.00	.96	.00	.00	.00	.00	.00	.00
WASTELOAD-2	12. WSL CY-FAIR MAT,HI	.00	5.40	.11	5.00	.00	.00	.06	6.50
WASTELOAD-2	13. WSL FAULKEY GULLY	.00	.00	.00	.00	.00	.00	.00	.00
WASTELOAD-2	14. WSL CARL FOREST STP	.00	7.00	.10	1.00	.00	.00	.00	22.00
WASTELOAD-2	15. WSL CHARTERWOOD MUD	.00	1.00	.10	10.00	.00	.00	.00	1.00
WASTELOAD-2	16. WSL TOMBALL HI SCH	.00	7.13	.15	1.06	.00	.00	.00	8.00
WASTELOAD-2	17. WSL PILLOT GULLY	.00	.00	.00	.00	.00	.00	.00	.00
WASTELOAD-2	18. WSL CY CHAMP PUD	.00	.00	.00	.00	.00	.00	.00	.00
WASTELOAD-2	19. WSL HARRIS CO. WCID 116	.00	15.00	.11	.33	.00	.00	.00	12.00
WASTELOAD-2	20. WSL DRY GULLY	.00	7.00	.10	15.00	.00	.00	.00	3.70
WASTELOAD-2	21. WSL [illegible] CENTRE	.00	7.40	.01	7.30	.00	.00	.00	1.30
WASTELOAD-2	22. WSL [illegible] CENTRE	.00	1.60	.10	25.80	.00	.00	.00	1.30
WASTELOAD-2	23. WSL CYPRESS HILL IN UD	.00	10.10	.10	2.00	.00	.00	.00	11.80
WASTELOAD-2	24. WSL SPRING GULLY	.00	6.80	.11	5.00	.00	.00	.00	8.00
WASTELOAD-2	25. WSL FUTURE25	.00	.00	.00	.00	.00	.00	.00	.00
WASTELOAD-2	26. WSL PONDEROSA WSTADR	.00	8.48	.14	3.65	.00	.00	.00	9.66
WASTELOAD-2	27. WSL CANDLELITE WCID 91	.00	11.70	.10	1.00	.00	.00	.00	13.70
WASTELOAD-2	28. WSL SEALY GULLY	.00	3.40	.10	8.60	.00	.00	.00	4.20
WASTELOAD-2	29. WSL CHP OF INTERIM	.00	.00	.00	.00	.00	.00	.00	.00
WASTELOAD-2	30. WSL WCID 0110	.00	7.20	3.75	2.05	.00	.00	.00	11.30
WASTELOAD-2	31. WSL NED WCID99-SPNPR	.00	3.10	.00	23.40	.00	.00	.00	4.00
WASTELOAD-2	32. WSL STONE-INVERNESS	.00	7.50	3.60	4.50	.00	.00	.00	9.00
WASTELOAD-2	33. WSL MEMORIAL HILLS	.00	8.40	.10	5.00	.00	.00	.00	8.40
WASTELOAD-2	34. WSL TIMBERLANE	.00	8.40	.10	7.00	.00	.00	.00	9.60
WASTELOAD-2	35. WSL THESCHOIS (01361)	.00	7.24	.05	.11	.00	.00	.00	8.30
WASTELOAD-2	36. WSL WILD CAT GULCH	.00	.00	.00	.00	.00	.00	.00	.00
WASTELOAD-2	37. WSL TURKEY CREEK	.00	.00	.00	.00	.00	.00	.00	.00
ENDATA11A		.00	.00	.00	.00	.00	.000		

Reproduced from
best available copy.



ATTACHMENT L: CALIBRATION — FEB. 11, 1976 SURVEY
RESPONSE CURVES
FOR CYPRESS CREEK MODEL

ATTACHMENT M

WASTEWATER TREATMENT PLANT DISCHARGE DESCRIPTION

Alternative Number: _____

Plant Name: _____

Waste Control Order Number: _____

Segment Name & Number: _____

Location:

Comments:

	Existing Discharge (12 Mos. Avg.)	Existing W.C.O. Limits	Proposed Discharge
Q (MGD)			
a) 30 day average	_____	_____	_____
b) 7 day average	_____	_____	_____
BOD_5 (mg/l)			
a) 30 day average	_____	_____	_____
b) 7 day average	_____	_____	_____
NH_3-N (mg/l)			
a) 30 day average	_____	_____	_____
b) 7 day average	_____	_____	_____
Fecal Coliform (#/100 ml.)	_____	_____	_____
Effluent D.O. (mg/l)	_____	_____	_____
Effluent Temp. (°C)	_____	_____	_____
Chlorine Residual (mg/l)	_____	_____	_____

WATER QUALITY MODELING

FOR THE

208 DESIGNATED PLANNING AREAS

HOUSTON AREA STEADY-STATE MODELING REPORTS

CLEAR CREEK ABOVE TIDAL - SEGMENT 1102

Prepared by:

Administrative Operations Division
Texas Water Quality Board
Austin, Texas

for the

Houston-Galveston Area Council

and the

U. S. Environmental Protection Agency

The preparation of this report was financed through planning grants from the U. S. Environmental Protection Agency through the Houston-Galveston Area Council.

May, 1977

TABLE OF CONTENTS

		PAGE
I.	INTRODUCTION	1
II.	DESCRIPTION OF STUDY AREA	1
III.	PRESENTATION OF DATA	2
	A) Historical Quality Problems	2
	B) Existing Water Quality	2
	C) Present Waste Loadings	3
	D) Hydrological Data	3
IV.	MATHEMATICAL MODEL FORMULATION	4
V.	MATHEMATICAL MODELING OF WATER QUALITY	5
	A) General	5
	B) Segmentation	6
	C) Hydraulics	6
	D) Atmospheric Reaeration	7
	E) Carbonaceous Demands	7
	F) Nitrogenous Demands	8
	G) Benthal Demands	8
	H) Photosynthesis/Respiration	8
	I) Coliforms	9
	J) Temperature Correction Factors	9
VI.	MODEL ANALYSIS	9
VII.	SENSITIVITY ANALYSIS	10
VIII.	RECOMMENDATIONS FOR MODEL USE	11
IX.	SUMMARY	13

LIST OF ATTACHMENTS

		PAGE
A	HOUSTON AREA - Segment Location Map	A-1
B-1	CLEAR CREEK - Segment 1102	B-1
B-2	MAP LEGEND - Clear Creek Above Tidal	B-2
C	TWQB STREAM MONITORING DATA - Clear Creek	C-1
D-1	CLEAR CREEK FIELD MEASUREMENTS September 16, 1976 TWQB INTENSIVE MONITORING SURVEY	D-1
D-2	CLEAR CREEK LABORATORY ANALYSES September 16, 1976 TWQB INTENSIVE MONITORING SURVEY	D-2
E	EXISTING WASTE LOADS ON CLEAR CREEK	E-1
F	CLEAR CREEK WASTE LOADS - September 16, 1976	F-1
G-1	CLEAR CREEK SCHEMATIC	G-1
G-2	SCHEMATIC EXPLANATION	G-2
H	CLEAR CREEK ABOVE TIDAL - QUAL-II Model Input	H-1
J	CALIBRATION - Response Curves for Clear Creek (Above Tidal) Model - September 16, 1976 Survey . .	J-1
K	WASTEWATER TREATMENT PLANT DISCHARGE DESCRIPTION . .	K-1

I. INTRODUCTION

This report has been prepared in accordance with an agreement between the Texas Water Quality Board and the Houston-Galveston Area Council covering the improvement of steady-state mathematical models of stream water quality for the Houston "208" Area. As required in TASK 2.63, the purpose of the report is to incorporate data obtained through TASK 2.62 into a steady-state stream model which can predict water quality along the non-tidal portion of Clear Creek (Segment 1102). The model used is a generalized steady-state model, QUAL-II, prepared for the Environmental Protection Agency by Water Resources Engineers, Inc., in May, 1973.

A general description of the study area along with past and present water quality conditions are discussed. The major waste dischargers are summarized. The choice of model and the significant physical and chemical parameters needed as input into the model are presented. The results of the model calibration/verification attempts are presented and discussed. An analysis to determine the sensitivity of the model parameters is included. A final section discusses the actual use of the model.

II. DESCRIPTION OF STUDY AREA

Clear Creek above tidal (Segment 1102) reaches from its headwaters in eastern Fort Bend County to the boundary of Segment 1101 just above FM 528 as shown in Attachment A. Clear Creek originates just north of Fresno from which it flows in a generally eastward direction. The length of the stream within the study area is approximately 31 miles from its headwaters to FM 528 which is located some 16 miles upstream of the mouth at Galveston Bay. Major tributaries within the study area include Cowart Bayou, Turkey Creek, Mary's Creek, Mud Gully, and Hickory Slough.

Since 1960, land use in the drainage area has changed from largely rural to high density residential development; this trend is projected to continue. Several oil fields are located in the area. One industrial operation and ten municipal facilities presently discharge along Clear Creek within the study area. Three industrial operations and one municipal facility hold no discharge permits.

III. PRESENTATION OF DATA

A) Historical Quality Problems

The Texas Water Quality Board maintains four water quality monitoring stations along the non-tidal portion of Clear Creek (see Attachment B) at Friendswood Link Road (Station No. 1102.005), FM 2351 (Station No. 1102.01), S. H. 35 (Station No. 1102.02), and FM 518 (Station No. 1102.03). A station is also maintained just below the segment boundary at FM 528 (Station No. 1101.01). Dissolved oxygen and fecal coliform standards for Segment 1102 are 5.0 mg/l and 2,000/100 ml, respectively. Water quality data gathered at these stations from October 1971 to January 1977 are shown in Attachment C and indicate that the segment has had problems with low dissolved oxygen levels and high fecal coliform counts.

Since 1971, two violations of the dissolved oxygen standard have been recorded at Friendswood Link Road. The dissolved oxygen concentration was 1.9 mg/l in September 1975 (stream temperature = 75°F) and 3.1 mg/l in October 1976 (66°F). At FM 2351, nine violations of the dissolved oxygen standard have been recorded. Five of the violations occurred in 1973. Since then, the dissolved oxygen concentration dropped to 4.1 mg/l in March 1974 (70°F), 4.5 mg/l in September 1975 (73°F), 4.4 mg/l in October 1975 (74°F), and 4.7 mg/l in October 1976 (75°F). Explanations for the dissolved oxygen violations include variations due to phytoplankton respiration and photosynthesis, flow variations from sewage treatment plants, plant upsets, sludge deposits, localized low stream velocities, and stormwater runoff.

The fecal coliform standard at FM 2351 was exceeded in two of seven samples in 1973, one of five samples in 1975, two of seven samples in 1976, and one of two samples in 1977. The fecal coliform data obtained at these stations were not collected at a frequency adequate to determine compliance with the logarithmic mean criterion.

B. Existing Water Quality

The City of Houston conducted water quality surveys on Clear Creek November 11, 1975 and December 9, 1975 in conjunction with the "208" modeling effort. These surveys were originally designed to provide data for model calibration and verification. Because of the chlorine toxicity

problems encountered, these surveys were considered inadequate to describe conditions along Clear Creek. On September 16, 1976, the Texas Water Quality Board conducted an intensive monitoring survey (IMS) along Clear Creek. Stream sampling stations were located at FM 528, Friendswood Link Road, FM 2351, S. H. 35, and FM 518 as shown in Attachment B.

Field measurements were taken once every four hours for twelve hours. The field parameters measured include dissolved oxygen, temperature, pH, and conductivity. Composite samples over the twelve-hour period were also taken at each station for laboratory analysis. The parameters measured in the laboratory include biochemical oxygen demand, ammonia nitrogen, nitrite nitrogen, nitrate nitrogen, total phosphorus, chlorophyll a, and total suspended solids. Total coliform and fecal coliform were also determined. A summary of the field measurements and laboratory analyses are shown in Attachment D.

Analysis of the data indicates that during the September 16, 1976 IMS, the average dissolved oxygen violated the standard at four of the five stations. The average dissolved oxygen concentration was 2.6 mg/l at FM 528, 2.7 mg/l at Friendswood Link Road, 3.9 mg/l at FM 235, and 4.9 mg/l at FM 518. Although the average dissolved oxygen concentration at S. H. 35 was above 5 mg/l, the dissolved oxygen concentration dropped to 4.8 mg/l once during the survey. As the data shows, Clear Creek is presently experiencing water quality problems based on TWQB water quality standards.

C) Present Waste Loadings

The average waste loadings during the period of January 1976 to September 1976 for dischargers along Clear Creek are presented in Attachment E. Attachment F summarizes the waste loadings during the September 16, 1976 IMS.

D) Hydrological Data

The United States Geological Survey maintains one continuous streamflow monitoring station on Clear Creek (above tidal) at S. H. 35 (Station No. 8077000). The flow at this station for September 16, 1976 was 2.4 cfs. The 7 day - 2 year low flow for Clear Creek at this station is 0.22 cfs.

IV. MATHEMATICAL MODEL FORMULATION

The steady-state model used for Clear Creek is QUAL-II, an expanded version of QUAL-I. The QUAL-II model was chosen because of its ability to rapidly predict water quality profiles in an advective system and because it is well-known and widely used in the field of modeling.

QUAL-II uses a set of interrelated differential mass transport equations to describe the effects of advection, dispersion, decay, sources, and sinks for all water quality constituents being modeled. The transport equations are then solved by numerical integration using an implicit-finite-difference technique under the assumption that advection along the primary axis of flow (longitudinal axis of the stream channel) is the primary mode of transport. QUAL-II is capable of simulating carbonaceous biochemical oxygen demand (BOD), nitrogenous BOD through the nitrogen cycle, benthic oxygen demand (BOD), nitrogenous BOD through the nitrogen cycle, benthic oxygen demand, dissolved oxygen (DO), the nutrient cycles, algae production, coliforms, and conservative materials.

A schematic diagram of the model structure is presented in Attachment G. River reaches, which are aggregates of computation elements of equal length, are defined for stretches of the stream with uniform hydraulic and reaction characteristics. Hydraulic coefficients and exponents, reaction rate coefficients, initial conditions, and incremental runoff are assumed to be constant for all computational elements within a reach. Each computational element is considered completely-mixed and therefore has uniform water characteristics throughout with the average concentration represented as to point value in the center of each element.

<u>Advantages</u>

1) QUAL-II models the nitrogen cycle from organic nitrogen to ammonia to nitrite to nitrate.

2) Benthal oxygen demand and coliforms are included in the model.

3) QUAL-II is capable of modeling the algae-nutrient interactions.

4) QUAL-II is capable of handling tributaries.

5) The implicit solution technique is unconditionally stable.

6) The output is easy to read and analyze. An excellent plotting routine helps in visualizing the effects of waste loads.

7) The documentation that supports the model is good and simplifies the job of programming of the model.

Disadvantages

1) Only longitudinal variations in water properties are possible.

2) Uniform properties and instant mixing are assumed for each computational element.

3) Reaches must have constant properties along them.

4) Only steady-state hydraulics are capable of being modeled. Therefore, QUAL-II does not lend itself to unsteady-state modeling.

5) Although QUAL-II includes algae-nutrient interactions, the approach is somewhat simplified.

V. MATHEMATICAL MODELING OF WATER QUALITY

A) General

Dissolved oxygen modeling in both advective and estuarine systems is basically an attempt to keep an account of the major sources and sinks of oxygen in a system composed of a number of complex interacting subsystems (reaches), each with its own set of physical characteristics. The primary sources of oxygen are: 1) dissolved oxygen in tributary inflow waters, and 2) atmospheric reaeration. In some cases, the action of algae will, through photosynthesis, add oxygen to water. The primary sinks for oxygen are: 1) carbonaceous demands, 2) nitrogenous demands, 3) benthic demands, and 4) biological respiration.

Hydrodynamic factors fix the transport of oxygen and oxygen-demanding materials in and out of each element in the reach. In a river or stream, this is accomplished by advection. In an estuary, these factors consist of dispersive and advective components, freshwater flow and circulation. These parameters are significantly affected by the geometry and shape of each reach in the system.

B) Segmentation

One of the first steps in stream modeling is to divide the stream into reaches of constant characteristics. New segments or reaches may be established due to changes in cross-sectional areas, depth, width or velocity. Additional flow from tributaries or wastewater discharges may require that a new segment be established. A spatial variation from benthal demand or photosynthesis and respiration parameters may require additional segmentation. The Clear Creek model was segmented into eighteen reaches. The main stem consists of ten reaches, and the tributaries, Hickory Slough, Mud Gully, Turkey Creek and Mary's Creek, consist of two reaches each.

C) Hydraulics

After a stream has been segmented, it is necessary to specify the hydraulic and physical characteristics of each segment on the stream systems. Two equations are generally used to describe the hydraulic characteristics. The equations represent the relationship between discharge and velocity and discharge and depth. These relationships can be represented by exponential equations as shown below:

$$V = aQ^b$$

$$D = cQ^d$$

where:

V = mean velocity in a reach

Q = mean discharge in a reach

D = mean depth

a, b, c, d = coefficients

The velocity equation was formulated using data gathered by Farner & Winslow, Inc., during the December 1975 time-of-travel study on Clear Creek. The depth equation was formulated from flow, velocity, and width measurements along Clear Creek. The velocity and depth equations for the lower reaches of Clear Creek were adjusted for the backwater and tidal effects of the tidal portion of Clear Creek.

D) Atmospheric Reaeration

The reaeration process is generally a function of temperature, stream geometry, and stream hydraulics. Several techniques and equations have been developed to estimate reaeration coefficients based on stream geometry and stream characteristics. The equations are generally in the form given by Streeter & Phelps (1925):

$$K_2 = \frac{c\,\bar{u}^n}{D^2}$$

where:

$\bar{u}$ = mean stream velocity

D = mean stream depth

c, n = constants for a particular stream

In the Clear Creek QUAL-II model, the O'Connor-Dobbins reaeration equation was used:

$$K_2\ (20°C) = \frac{12.84\ \bar{u}^{.5}}{D^{1.5}}$$

E) Carbonaceous Demands

Wastewater discharges from various types of treatment plants generally contain organic materials which will decompose in the presence of oxygen and certain bacteria. The bacteria which degrade the carbonaceous component of these organic materials are present in most waters and they begin the process of decomposition quickly. Carbonaceous oxygen demand is usually determined in the five-day biochemical oxygen demand test (BOD_5). In this test, the amount of oxygen consumed under aerobic conditions, at 20°C, is measured. It is frequently assumed that the ultimate carbonaceous demand is equal to 1.5 times the five-day oxygen demand. The BOD values input into the Clear Creek model are ultimate BOD values determined by multiplying the BOD_5 by 1.5.

Carbonaceous decay rates are usually determined from plotting the stream BOD values downstream of a discharger against the time-of-travel down the stream. The slope

of the line is the decay rate. This method proved unacceptable for Clear Creek due to the large number of discharges which prevented isolating one BOD profile. The decay rates were adjusted so that the predicted BOD profiles matched the observed BOD profiles.

F) Nitrogenous Demands

Various nitrogen compounds exert an oxygen demand as they change from one form to another. These changes in form require the presence of a specific bacterial population. This population is not always available in sufficient numbers to cause these changes, and under these circumstances, a delay or lag time is sometimes observed in the exertion of nitrogenous oxygen demand. The conversion of organic nitrogen to ammonia nitrogen is assumed to take place by hydrolysis and therefore exerts no oxygen demand. The conversion of ammonia nitrogen to nitrite nitrogen exerts an oxygen demand of 3.43 mg oxygen/mg nitrogen. The conversion of nitrite nitrogen to nitrate nitrogen exerts an oxygen demand of 1.14 mg oxygen/mg nitrogen.

The three nitrogenous decay rates were obtained from literature values. These rates were then adjusted to provide a reasonable fit between the predicted values and the observed values.

G) Benthal Demands

Bottom deposits, generally in the form of sludges discharged from municipal or industrial wastewater treatment plants, can exert an oxygen demand. These sludges accumulate below wastewater outfalls when stream velocities are not sufficient to keep solid particles in suspension. These sludges can exert an oxygen demand of from 5.0 to 1,000 milligrams of oxygen per square foot of bottom area per day. At higher treatment levels, the benthal demand will be reduced due to the reduction in discharged solids.

H) Photosynthesis/Respiration

The presence of algae can also have an effect on dissolved oxygen in surface waters. During periods of daylight, oxygen is produced as a by-product of photosynthesis. Oxygen is consumed during respiration. This complex system, involving both a source and sink of oxygen, frequently results in a diurnal variation in dissolved oxygen concentrations. The photosynthesis/respiration system can result

in either a surplus or deficit of oxygen depending on a number of conditions including light intensities, available nutrients, and turbidity.

I) Coliforms

Because of the previously noted high chlorine residuals, the coliform data collected on Clear Creek proved unacceptable for coliform calibration. Therefore, a literature value of 0.1 $days^{-1}$ was chosen as the die-off rate.

J) Temperature Correction Factors

Many of the reactions which determine water quality in natural systems are dependent on temperature. This dependence is usually considered by changing the various rate constants according to the following equation:

$$K_T = K_{20}\,\theta^{(T-20)}$$

where K_T and K_{20} are rate constants at a temperature, T, and a 20° Centigrade, and θ is a temperature correction factor which depends on the reaction being considered. The following temperature correction factors are used:

Reaction	θ, Temperature Correction Factor
Atmospheric Reaeration	1.0159
Carbonaceous Decay	1.047
Nitrogenous Decay	1.047
Benthal Demand	1.065
Coliform Die-off	1.047

QUAL-II corrects all of above except benthal demand for temperature. The benthal demand must be corrected for temperature by hand before being input to the model.

VI. MODEL ANALYSIS

A calibration of the QUAL-II model for the Clear Creek was made using data gathered by the Texas Water Quality Board

self-reporting data. The input data is given in Attachment H. The calibration is shown in Attachment J. Good agreement is shown between the calculated and the observed values for dissolved oxygen and biochemical oxygen demand. Minor differences between calculated and observed values may be attributed to numerous causes including but not limited to: a possible lack of steady-state conditions during the survey, unaccounted non-point sources of pollution, chlorine toxicity and inhibition, the possible presence of algae, and sampling and measurement errors. Given the reasonably good agreement shown in the calibration, the QUAL-II computer simulation model for Clear Creek, discussed in this report, can be used to evaluate a variety of alternative treatment schemes for Clear Creek.

VII. SENSITIVITY ANALYSIS

The output of any water quality simulation model depends on the hydraulics, rates, and waste loads which are input to the model. A list of the input values is given in Attachment H. It is useful to determine the sensitivity of this output to changes in input values. In the following sensitivity analysis, all but one parameter are held constant, and the remaining parameter value is varied by ± 20% about the value used in the calibrated model. The selection of a 20% variation is purely arbitrary. The following table lists changes in the dissolved oxygen at a critical point in the dissolved oxygen profile. The point chosen is at river mile 24 of Clear Creek and has a value of 2.68 mg/l in the calibrated model. The table shows only relative sensitivity of model output to changes in the input values.

Sensitivity of Model Output to Changes in Input Parameters. Dissolved Oxygen Concentrations at River Mile 24

Parameter	-20%*	+20%*	Difference
Stream Depth	4.11	1.18	2.93
K1, BOD Decay Rate	4.37	2.58	1.79
Effluent Flow	3.46	1.96	1.50

Parameter	-20%*	+20%*	Difference
Temperature	3.14	2.24	0.90
Effluent NH_3	3.33	2.57	0.76
KNH3, NH_3, Decay Rate	4.54	4.19	0.35
Effluent BOD	2.89	2.47	0.42
Headwater Flow	2.55	2.80	0.25
Stream Velocity	2.61	2.79	0.18
Benthal Demand	2.74	2.62	0.12

*For temperature, $\pm$ 4°F

The table indicates that depth, BOD decay rate, and effluent flow have the greatest relative effect on the calibrated model.

VIII. RECOMMENDATIONS FOR MODEL USE

It should be understood that the model calibration described in this report describes only a single set of conditions which existed in Clear Creek during a particular set of conditions (flow, waste loads, temperature, etc.). Very careful consideration must be given to any changes in the listed input conditions. A change in one parameter might easily necessitate some change in a related rate or coefficient. For this reason, any alternate treatment scheme which is sent to the Texas Water Quality Board for evaluation of receiving water quality impact must be adequately described. Attachment K at the end of this report should be used to describe these alternate treatment schemes.

Some general comments can be made concerning the alternative runs without knowing the specifics of each alternative treatment scheme. The following recommendations are meant only as a general statement of parameter changes.

Hydraulics - The coefficients and exponents will be considered acceptable for low flow conditions in the range of those used in calibrating this model. If large changes in flow conditions occur, changes in the coefficients and exponents may be necessary.

Reach	Rate
11	330
12	330
13	330
14	330
15	330
16	330
17	460
18	460

Because of the high chlorine residuals found in the streams, coliform calibration was impossible. An assumed coliform decay rate of 0.1 is to be used in the model. If evidence suggests using some other rate, we will consider changing it.

Initial Conditions - Only the steady-state temperature need be specified. It will be input according to conditions being modeled.

Runoff Conditions - Runoff conditions will be input according to conditions being modeled.

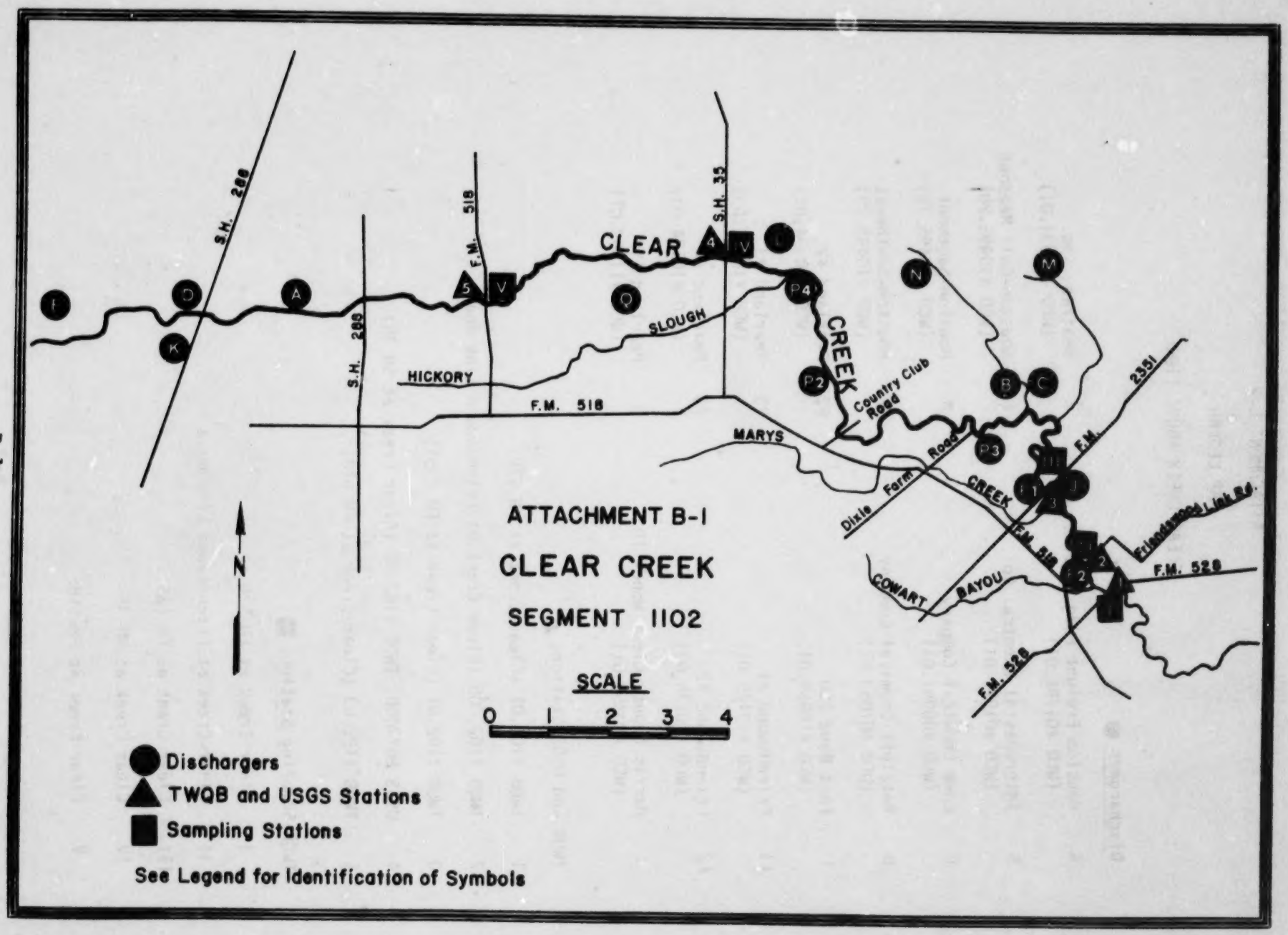
Headwater - Headwater conditions will be input according to conditions being modeled.

Waste Loads - Wasteloads will be input according to the alternative being modeled. BOD is ultimate BOD (1.5 x BOD_5). Organic nitrogen, ammonia, nitrite, and nitrate are entered as nitrogen (no oxygen equivalent factors are necessary.

IX. SUMMARY

The staff of the Texas Water Quality Board has reviewed the data gathered in Clear Creek by the City of Houston. Using the data and monitoring data from the Texas Water Quality Board, a one-dimensional steady-state computer model has been calibrated for use by the Texas Water Quality Board and related planning agencies.

ATTACHMENTS


ATTACHMENT B-1
CLEAR CREEK
SEGMENT 1102
SCALE
0 1 2 3 4
N
Dischargers
TWQB and USGS Stations
Sampling Stations
See Legend for Identification of Symbols
CLEAR
CREEK
SLOUGH
HICKORY
MARYS
COWART
BAYOU
S.H. 288
S.H. 35
F.M. 518
F.M. 2351
F.M. 528
Country Club Road
Dixie Farm Road
Friendswood Link Rd.

ATTACHMENT B-2

MAP LEGEND

CLEAR CREEK ABOVE TIDAL

Dischargers ●

A Houston Freight Fwdg. Co. (WCO #01796.01)

B Intercoastal Chemical Co. (WCO #01571.01)

C Lowe Chemical Company (WCO #00951.01)

D Retzloff Chemical Company (WCO #01053.01)

E Fort Bend ISD (WCO #10950.01)

F1 Friendswood #1 (WCO #10175.01)

F2 Friendswood #2 (WCO #10175.02)

J Harris County Clear Woods ID (WCO #10858.01)

K Heatran, Inc. (WCO #11631.01)

L Houston-Gulf Meadows (WCO #10495.20)

M Houston-Sagemont (WCO #10495.75)

N Houston-Southeast (WCO #10495.79)

P2 Pearland #2 (WCO #10134.02)

P3 Pearland #3 (WCO #10134.03)

P4 Pearland #4 (WCO #10134.04)

Q Pearland ISD (WCO #11362.01)

TWQB and USGS Stations ▲

1 TWQB 1101.01 (Clear Creek at FM 528)

2 TWQB 1102.005 (Clear Creek at Friendswood Link Road)

3 TWQB 1102.01 (Clear Creek at FM 2351)

4 USGS 8077000; TWQB 1102.02 (Clear Creek at SH 35)

5 TWQB 1102.03 (Clear Creek at FM 518)

TWQB Sampling Stations ■

I Clear Creek at FM 528

II Clear Creek at Friendswood Link Road

III Clear Creek at FM 2351

IV Clear Creek at SH 35

V Clear Creek at FM 518

ATTACHMENT C

TWQB STREAM MONITORING DATA
CLEAR CREEK

Reproduced from best available copy.

STATION NO. 1101.0150

STATION LOCATION
BRIDGE OF F. M. 528 SOUTHEAST OF FRIENDSWOOD

SAMPLE DATE	TIME	DEPTH (FT.)	SOURCE AGENCY	STREAM FLOW CFS	WATER TEMP FAHR	FEC COLI /100ML	DO MG/L	BOD 5 DAY MG/L	NH3-N TOTAL MG/L	T PO4 PO4 MG/L	CHLORPHYL A MG/L	PH SU	RESIDUE TOT NFLT MG/L	NO3-N TOTAL MG/L	CHLORIDE CL MG/L	SULFATE SO4 MG/L	RESIDUE DISS-50C CON.MG/L	CNDUCTVY AT 25C MICROMHO	TURB JKSN JTU
10/19/71	1300	1.0																	
10/19/71	1300	3.0			78.0	2300.*	1.8*	3.5	.100	13.50									
10/19/71	1300	7.0																	
11/26/71	1700	1.0											10.	1.00	383.	44.	1050.	1950.	10.0
12/30/71	1630	1.0			61.0												4000.		
01/13/72	1650	1.0			68.0		4.2	2.5	44.000	24.50							6500.		
02/17/72	1315	1.0			64.0		3.9*	2.8	1.420	7.40			72.	1.10	316.	50.			
03/17/72	1630	1.0			62.0		2.4*	3.0	3.560	8.90			20.	.48	265.	37.		1545.	
04/19/72	0930	1.0			70.0		7.2						10.	.71	334.	42.		2950.	
04/19/72	0930	5.0			74.0		3.4*											3675.	
04/19/72	0930	10.0			72.0	4600.*	1.4*	2.6	5.260	1.30	.060	6.70							15.0
05/30/72	1530	1.0			70.0		.5					7.70							170.0
06/15/72	1325	1.0			85.0		.1						10.	.30	546.	70.	375.		55.0
07/05/72	1125	1.0			84.0		9.0										800.	1600.	25.0
08/22/72	1512	1.0			82.0		4.0										3900.		
09/14/72	1030	1.0			84.0	15000.*	2.0*	3.3	.630	5.88	.020	8.10					7000.		
10/31/72	1045	1.0			79..		4.2					7.40					750.		
11/22/72	1415	1.0			72.0		2.4*						10.	.07	280.	57.	450.		20.0
12/07/72	1545	1.0			86.0	240.	2.8*	4.2	.980	2.45	.007	7.90						4620.	50.0
01/22/73	1550	1.0			75.0		3.2*					7.30							20.0
02/27/73	0845	1.0			68.0		4.0						10.	.36	176.	36.	700.		40.0
03/30/73	1000	1.0			58.0		3.4*					7.50						1360.	30.0
04/26/73	0845	1.0			65.0	11000.*	6.0	2.7	.440	3.46	.015	7.40					680.		25.0
05/23/73	0910	1.0			75.0		5.6	2.0	.500	2.94	.009	6.70					750.		35.0
06/20/73	0945	1.0			77.0	4600.*	2.8*	3.0	.470	3.19	.006		180.	.28	131.	25.	375.		50.0
07/31/73	1115	1.0			79.0		2.6*	3.0	.560	6.40	.030		100.	.33	127.	16.		1060.	
09/16/73	1145	1.0	TWQB		87.0	1300.	3.0*						100.	.47	131.	18.		800.	
03/11/76	1530	1.0	TWQB		77.0	1800.	3.0*	4.0	.000	4.14	.017		30.	.91	300.	20.		1020.	
05/25/76	1330	1.0	TWQB		66.2	530.	.6*	2.5	1.300	1.45	.000							1350.	
10/27/76	1220	1.0	TWQB		81.0	40.		9.7	.080	3.55	.001	7.40	50.	.35	171.	30.			65.0
10/27/76	1225	12.0	TWQB		64.0	200.	3.2*	4.0	1.490	4.31	.027	7.70	16.	.83	187.	39.		1200.	45.0
12/20/76	1125	1.0	TWQB		69.1			2.0	1.670	5.86	.002		73.	2.48	190.	46.	550.		45.0
12/20/76	1130	10.0	TWQB		55.8	10.						7.80	16.	1.32	400.	425.	990.		20.0
01/20/77	1210	1.0	TWQB		57.4			2.0	.300	.99	.001		13.	2.32	1225.	99.			95.0
01/20/77	1220	10.0	TWQB		47.3	10.						7.46							20.0
					46.4			2.0	.780	3.69	.002	7.50	67.	.21	61.	38.	275.		25.0
												7.50	26.	.68	207.	49.	275.		120.0
												7.60					400.		
																	420.		30.0

STATION SUMMARY

AVERAGE	70.9	96.	3.3	3.2	3.533	5.66	.014				44.	.78	311.	63.	1577.	1945.	48.1
GEOMETRIC MEAN																	
MAXIMUM	87.0	1800.	9.0	9.7	44.000	24.50	.060	8.10	180.	2.48	1225.	425.	7000.	4620.		170.0
MINIMUM	46.4	10.	.5	2.0	.080	.98	.000	6.70	10.	.07	65.	16.	275.	800.		10.0
SECOND HIGHEST SAMPLE	86.0	530.	7.2	4.2	5.260	13.50	.030	7.90	100.	2.22	546.	95.	6500.	3675.		120.0
SECOND LOWEST SAMPLE	47.3	10.	.5	2.0	.080	1.30	.001	6.70	10.	.20	128.	16.	275.	1020.		15.0
NUMBER OF SAMPLES	33	6	27	18	18	18	14	16	17	18	18	18	19	17		21

EFFECTIVE DATE: 10/25/73
DEPTH: 1.0

SEGMENT STANDARDS

	STREAM FLOW CFS	WATER TEMP FAHR	FEC COLI /100ML	DO MG/L	BOD 5 DAY MG/L	NH3-N TOTAL MG/L	T PO4 PO4 MG/L	CHLORPHYL A MG/L	PH SU	RESIDUE TOT NFLT MG/L	NO3-N TOTAL MG/L	CHLORIDE CL MG/L	SULFATE SO4 MG/L	RESIDUE DISS-50C CON.MG/L	CNDUCTVY AT 25C MICROMHO	TURB JKSN JTU
MAXIMUM		95.0	2000.						9.00							
MINIMUM				4.0					6.50							

AN ASTERISK (*) DENOTES A MEASUREMENT THAT IS NOT WITHIN STANDARDS.

STATION NO. 1102.0950 — STATION LOCATION AT PRINCEWOOD LINK ROAD AT POTTERSBURG

SAMPLE DATE	TIME	DEPTH (FT.)	SOURCE AGENCY	STREAM FLOW CFS	WATER TEMP FAHR	FEC COLI /100ML	DO MG/L	BOD 5 DAY MG/L	NO3-N TOTAL MG/L	T PO4 PO4 MG/L	CHLORYL A MG/L	PH SU	RESIDUE TOT NFLT MG/L	NO3-N TOTAL MG/L	CHLORIDE CL MG/L	SULFATE SO4 MG/L	RESIDUE DISS-NFR CON.MG/L	CONDCTVY AT 25C MICROMHO	TURB JKSN JTU
12/27/71	1145	1.0	T400		48.4							7.60							
09/16/75	1100	1.0	T400		75.2	80.	1.0*	2.0	1.000	3.16	.001	7.40	35.	1.60	175.	40.			30.0
03/11/76	1045	1.0	T400		46.2	510.					.001	7.40					350.		105.0
05/25/76	1215	1.0	T400			80.													
10/27/76	1145	1.0	T400		46.0	170.	3.1*	2.0	1.430	4.70	.001	7.30	35.	1.80	1200.*	44.			40.0
10/27/76	1150	9.0	T400		46.0														
12/20/76	1055	1.0	T400		39.0	900.						7.30					250.		120.0
01/20/77	1145	1.0	T400			190.											300.		25.0
01/20/77	1155	9.0	T400		47.1							7.60					300.		
STATION SUMMARY																			
AVERAGE					48.7		2.5	2.0	1.215	2.95	.001		35.	1.77	688.	52.	300.		60.0
GEOMETRIC MEAN						205.													
MAXIMUM					75.2	900.	3.1	2.0	1.430	4.70	.001	7.60	35.	1.80	1200.	60.	350.		120.0
MINIMUM					47.1	80.	1.0	2.0	1.000	1.16	.001	7.40	35.	1.60	175.	44.	250.		25.0
SECOND HIGHEST SAMPLE					46.0	510.	1.0	2.0	1.000	1.16	.001	7.40	35.	1.65	175.	44.	300.		105.0
SECOND LOWEST SAMPLE					48.4	80.	3.1	2.0	1.430	4.70	.001	7.30	35.	1.80	1200.	60.	300.		30.0
NUMBER OF SAMPLES					7	6	2	2	2	2	3	6	2	2	2	2	6		5

EFFECTIVE DATES: 10/25/73 DEPTH: 1.0	STREAM FLOW CFS	WATER TEMP FAHR	FEC COLI /100ML	DO MG/L	BOD 5 DAY MG/L	NO3-N TOTAL MG/L	T PO4 PO4 MG/L	CHLORYL A MG/L	PH SU	RESIDUE TOT NFLT MG/L	NO3-N TOTAL MG/L	CHLORIDE CL MG/L	SULFATE SO4 MG/L	RESIDUE DISS-NFR CON.MG/L	CONDCTVY AT 25C MICROMHO	TURB JKSN JTU
SEGMENT STANDARDS																
MAXIMUM		95.0	2000.						8.50			250.	100.	400.		
MINIMUM				5.0					6.50							

AN ASTERISK (*) DENOTES A MEASUREMENT THAT IS NOT WITHIN STANDARDS.

Reproduced from best available copy.

STATION NO. 1102.0150 — STATION LOCATION AT PAPPY WEST OF WEBSTER

SAMPLE DATE	TIME	DEPTH (FT.)	SOURCE AGENCY	STREAM FLOW CFS	WATER TEMP FAHR	FEC COLI /100ML	DO MG/L	BOD 5 DAY MG/L	NO3-N TOTAL MG/L	T PO4 PO4 MG/L	CHLORYL A MG/L	PH SU	RESIDUE TOT NFLT MG/L	NO3-N TOTAL MG/L	CHLORIDE CL MG/L	SULFATE SO4 MG/L	RESIDUE DISS-NFR CON.MG/L	CONDCTVY AT 25C MICROMHO	TURB JKSN JTU
09/23/73	0910	1.0	T400		68.0	900.	3.8*	4.0	.600	3.60	.011		50.	.90	325.*	126.*		1070.	63.0
06/30/74	0905	1.0	T400		77.0	79000.*	8.8*	6.0	.000				137.	.40	50.	25.		250.	110.0
09/10/74	0900	1.0	T400		77.0	110.	4.6*	1.0	1.000	6.24			85.	1.00	100.	110.*		1500.	60.0
09/26/74	0930	1.0	T400		79.0	490.	3.8*	2.0	2.100	7.01			121.	.95	75.	32.		940.	55.0
10/11/74	0920	1.0	T400		79.0	730.	3.2*	2.0	1.800	6.54			99.	1.14	200.	20.		1100.	55.0
10/23/74	0900	1.0	T400		69.0	350.	5.6	1.0	1.600	6.77			135.	.46	75.	20.		550.	55.0
11/26/74	0855	1.0	T400		73.0	4100.*	5.1	1.0	.900	7.18			26.	1.03	150.	36.		840.	65.0
12/12/74	0855	1.0	T400		58.0		7.5		5.000	11.70			16.	1.55	190.	17.		1000.	20.0
02/25/75	0845	1.0	T400		51.0	500.	8.1		1.600	15.20			42.	1.15	205.*	37.		1100.	35.0
03/17/75	1000	1.0	T400		78.0		6.1*					7.70					940.*		40.0
04/09/75	1050	1.0	T400		65.0	1700.	6.7		.900	7.00	.000		40.	1.10	170.	41.		1140.	
05/20/75	0855	1.0	T400		79.0		5.2					7.60					400.		75.0
06/18/75	0950	1.0	T400		83.0		5.0					8.30					460.		1.0
07/10/75	1000	1.0	T400		82.0	1100.	5.3		1.000	2.41	.023		89.	.40	145.	80.		700.	
08/21/75	0850	1.0	T400		83.0		5.9					8.20					525.		40.0
09/11/75	0930	1.0	T400		77.0		5.5					8.10					550.		25.0
10/21/75	0845	1.0	T400		77.0	400.	6.0		1.000	3.04			15.	4.20	200.	44.		1200.	
11/06/75	0900	1.0	T400		69.0		6.2					8.10					400.		35.0
12/18/75	0900	1.0	T400		62.0		8.1					8.30					475.*		40.0
01/16/75	1045	1.0	T400		52.0	1700.	9.5		11.000	6.50			105.	.81	94.	35.		700.	
02/19/75	0925	1.0	T400		56.0		7.2					7.60					725.*		40.0
03/18/75	0855	1.0	T400		61.0		8.0					7.70					390.		400.0
04/10/75	0855	1.0	T400		71.0	200.	5.5		1.000	.90			45.	3.01	205.*	60.		1200.	
07/17/75	1055	1.0	T400		81.0	400.	6.0	3.0	1.000	.60			149.	.92	70.	36.	994.	600.	140.0
09/16/75	0945	1.0	T400		75.4	300.	6.5*	1.0	1.000	.54	.001	7.30	15.	2.15	180.	54.			30.0
10/23/75	1045	1.0	T400		74.0	2500.*	6.6*		1.000	.00	.015		100.	1.67	170.	80.		1000.	
01/06/76	1055	1.0	T400		58.0	10.	9.5	2.0			.000		56.	1.21	115.	54.		750.	
03/11/76	1510	1.0	T400		66.2	560.		4.0	30.500	3.30	.001	7.80	29.	3.30	145.	55.	600.		75.0
04/07/76	1025	1.0	T400		70.0	1500.	7.5		.170	.00			114.	2.42	115.	50.	487.	900.	180.0
05/25/76	1250	1.0	T400		80.1	2700.*		3.0	.970	4.41	.001		75.	1.27	75.	60.	350.		60.0
07/14/76	0930	1.0	T400		77.0	8500.*	6.5		.290	.00	.015		550.	.21	80.	36.	254.	300.	190.0
10/06/76	0905	1.0	T400		75.0	300.	6.7*		.040	6.00	.004		15.	2.04	167.			1200.	30.0
10/27/76	1110	1.0	T400		65.0	240.	5.5	2.0	1.000	7.57	.001	7.70	45.	2.30	495.*	29.			40.0
12/20/76	1030	5.0	T400		56.1							7.50					250.		
01/10/77	1045	1.0	T400		43.0	13000.*			.200	1.25	.007	7.10	1.	.21	35.	26.	150.	990.	180.0
01/20/77	1030	1.0	T400		44.6	10.		2.0	.520	4.39	.001	7.60	26.	1.00	125.	90.	310.		40.0
STATION SUMMARY																			
AVERAGE					69.0		6.0	2.4	3.019	4.06	.007		92.	1.68	159.	53.	457.	840.	94.3
GEOMETRIC MEAN						491.													
MAXIMUM					83.0	79000.	9.5	6.0	30.500	15.20	.023	8.30	990.	4.20	495.	126.	750.	1500.	400.0
MINIMUM					43.0	10.	5.2	1.0	.000	.00	.000	7.10	1.	.21	35.	20.	150.	250.	25.0
SECOND HIGHEST SAMPLE					83.0	13000.	9.1	6.0	11.000	11.70	.019	8.30	337.	2.19	326.	110.	725.	1200.	190.0
SECOND LOWEST SAMPLE					44.6	10.	5.2	1.0	.170	.00	.000	7.30	15.	.46	55.	22.	250.	300.	25.0
NUMBER OF SAMPLES					36	25	29	34	25	26	13	15	26	26	26	25	17	21	28

EFFECTIVE DATES: 10/25/73 DEPTH: 1.0	STREAM FLOW CFS	WATER TEMP FAHR	FEC COLI /100ML	DO MG/L	BOD 5 DAY MG/L	NO3-N TOTAL MG/L	T PO4 PO4 MG/L	CHLORYL A MG/L	PH SU	RESIDUE TOT NFLT MG/L	NO3-N TOTAL MG/L	CHLORIDE CL MG/L	SULFATE SO4 MG/L	RESIDUE DISS-NFR CON.MG/L	CONDCTVY AT 25C MICROMHO	TURB JKSN JTU
SEGMENT STANDARDS																
MAXIMUM		95.0	2000.						8.50			250.	100.	400.		
MINIMUM				5.0					6.50							

AN ASTERISK (*) DENOTES A MEASUREMENT THAT IS NOT WITHIN STANDARDS.

STATION NO. 1102.0200 — STATION LOCATION AT SH 35 NORTH OF PEARLAND

SAMPLE DATE	TIME	DEPTH (FT.)	SOURCE AGENCY	STREAM FLOW CFS	WATER TEMP FAHR	FEC COLI /100ML	DO MG/L	BOD 5 DAY MG/L	NH3-N TOTAL MG/L	T PO4 PO4 MG/L	CHLRPHYL A MG/L	PH SU	RESIDUE TOT NFLT MG/L	NO3-N TOTAL MG/L	CHLORIDE CL MG/L	SULFATE SO4 MG/L	RESIDUE DISS-SOL COR.MG/L	CNDUCTVY AT 25C MICROMHO	TURB JKSN JTU
09/15/75	1130	1.0	THOP	2.7	73.4	350.	7.7	2.0	1.000	.40	.001	7.70	62.	.03	100.	32.			55.0
03/11/76	1645	1.0	THOP	0.98	68.0	440.		8.0	.010	.10	.001	8.50	15.	.04	260.*	54.	650.*		20.0
05/25/76	1200	1.0	THOP	17.0	96.1	370.		4.0	.310	.58	.027		224.	.05	69.	25.	300.		190.0
10/27/76	1034	1.0	THOP		59.0	270.	8.3	2.0	.020	.25	.003	8.00	35.	.04	85.	39.			40.0
12/28/76	0950	1.0	THOP		56.0	800.		2.0	.050	.35	.001	7.40	31.	.01	45.	32.	250.		160.0
01/20/77	1000	1.0	THOP		42.1	150.		2.0	.010	.20	.001	7.50	19.	.01	130.	54.	290.		25.0

STATION SUMMARY

	WATER TEMP FAHR	FEC COLI /100ML	DO MG/L	BOD 5 DAY MG/L	NH3-N TOTAL MG/L	T PO4 PO4 MG/L	CHLRPHYL A MG/L	PH SU	RESIDUE TOT NFLT MG/L	NO3-N TOTAL MG/L	CHLORIDE CL MG/L	SULFATE SO4 MG/L	RESIDUE DISS-SOL COR.MG/L	CNDUCTVY AT 25C MICROMHO	TURB JKSN JTU
AVERAGE	62.7		7.6	1.3	.253	.31	.004		65.	.03	114.	40.	372.		65.0
GEOMETRIC MEAN		350.													
MAXIMUM	80.1	800.	8.3	8.0	1.000	.58	.027	8.50	224.	.05	260.	54.	650.		190.0
MINIMUM	42.1	150.	7.0	2.0	.010	.10	.001	7.40	15.	.01	45.	25.	250.		20.0
SECOND HIGHEST SAMPLE	75.4	440.	7.0	4.0	.310	.40	.003	8.00	62.	.04	130.	44.	300.		190.0
SECOND LOWEST SAMPLE	54.0	270.	8.3	2.0	.010	.20	.001	7.50	19.	.01	85.	32.	290.		25.0
NUMBER OF SAMPLES	6	6	3	6	6	6	6	5	6	6	6	6	4		6

EFFECTIVE DATE: 10/27/73
DEPTH: 1.0

SEGMENT STANDARDS

	STREAM FLOW CFS	WATER TEMP FAHR	FEC COLI /100ML	DO MG/L	BOD 5 DAY MG/L	NH3-N TOTAL MG/L	T PO4 PO4 MG/L	CHLRPHYL A MG/L	PH SU	RESIDUE TOT NFLT MG/L	NO3-N TOTAL MG/L	CHLORIDE CL MG/L	SULFATE SO4 MG/L	RESIDUE DISS-SOL COR.MG/L	CNDUCTVY AT 25C MICROMHO	TURB JKSN JTU
MAXIMUM		95.0	2000.						8.50			200.	100.	600.		
MINIMUM				5.0					6.50							

AN ASTERISK (*) DENOTES A MEASUREMENT THAT IS NOT WITHIN STANDARDS.

Reproduced from best available copy.

STATION NO. 1102.0300 — STATION LOCATION AT FM 518 NORTHWEST OF PEARLAND

SAMPLE DATE	TIME	DEPTH (FT.)	SOURCE AGENCY	STREAM FLOW CFS	WATER TEMP FAHR	FEC COLI /100ML	DO MG/L	BOD 5 DAY MG/L	NH3-N TOTAL MG/L	T PO4 PO4 MG/L	CHLRPHYL A MG/L	PH SU	RESIDUE TOT NFLT MG/L	NO3-N TOTAL MG/L	CHLORIDE CL MG/L	SULFATE SO4 MG/L	RESIDUE DISS-SOL COR.MG/L	CNDUCTVY AT 25C MICROMHO	TURB JKSN JTU
09/15/75	0945	1.0	THOP		71.6	240.	6.9	1.	1.000	.49	.001	7.90	23.	.04	220.*	44.			35.0
03/11/76	1720	1.0	THOP		68.9	50.					.001	8.30					800.*		35.0
05/25/76	1130	1.0	THOP			850.						8.60*	36.	.01	110.	42.			25.0
10/27/76	1005	1.0	THOP		57.9	100.	7.6	2.0	.010	.14	.001	6.80					200.		45.0
12/28/76	0915	1.0	THOP		55.2	900.	8.4					7.10					310.		40.0
01/20/77	0955	1.0	THOP		41.2	70.													35.0

STATION SUMMARY

	WATER TEMP FAHR	FEC COLI /100ML	DO MG/L	BOD 5 DAY MG/L	NH3-N TOTAL MG/L	T PO4 PO4 MG/L	CHLRPHYL A MG/L	PH SU	RESIDUE TOT NFLT MG/L	NO3-N TOTAL MG/L	CHLORIDE CL MG/L	SULFATE SO4 MG/L	RESIDUE DISS-SOL COR.MG/L	CNDUCTVY AT 25C MICROMHO	TURB JKSN JTU
AVERAGE	59.0		7.8	1.5	.505	.32	.001		29.	.02	169.	43.	437.		36.0
GEOMETRIC MEAN		200.													
MAXIMUM	71.6	900.	8.4	2.0	1.000	.49	.001	8.60	36.	.04	220.	44.	800.		45.0
MINIMUM	41.2	50.	6.9	1.0	.010	.14	.001	6.80	23.	.01	110.	42.	200.		25.0
SECOND HIGHEST SAMPLE	68.9	850.	7.6	1.0	.010	.14	.001	8.30	23.	.01	110.	42.	310.		40.0
SECOND LOWEST SAMPLE	55.2	70.	7.6	2.0	1.000	.49	.001	7.10	36.	.04	220.	44.	310.		35.0
NUMBER OF SAMPLES	5	6	3	2	2	2	3	5	2	2	2	2	3		5

EFFECTIVE DATE: 10/25/73
DEPTH: 1.0

SEGMENT STANDARDS

	STREAM FLOW CFS	WATER TEMP FAHR	FEC COLI /100ML	DO MG/L	BOD 5 DAY MG/L	NH3-N TOTAL MG/L	T PO4 PO4 MG/L	CHLRPHYL A MG/L	PH SU	RESIDUE TOT NFLT MG/L	NO3-N TOTAL MG/L	CHLORIDE CL MG/L	SULFATE SO4 MG/L	RESIDUE DISS-SOL COR.MG/L	CNDUCTVY AT 25C MICROMHO	TURB JKSN JTU
MAXIMUM		95.0	2000.						8.50			200.	100.	600.		
MINIMUM				5.0					6.50							

AN ASTERISK (*) DENOTES A MEASUREMENT THAT IS NOT WITHIN STANDARDS.

ATTACHMENT D-1

CLEAR CREEK FIELD MEASUREMENTS
SEPTEMBER 16, 1976 TWQB INTENSIVE MONITORING SURVEY

Station Location	Dissolved Oxygen (mg/l)		Temperature (°F)		Average pH	Average Conductivity (μmhos/cm)
	Range	Average	Range	Average		
FM 528	1.8-4.1	2.6	77-83	80	7.0	10,483
Friendswood Link Road	1.3-4.0	2.7	79-82	81	7.2	5,913
FM 2351	3.4-4.1	3.9	79-81	80	7.8	1,525
SH 35	4.8-7.8	6.4	77-82	80	8.4	1,069
FM 518	3.8-5.8	4.9	77-83	80	8.2	1,113

ATTACHMENT D-2

CLEAR CREEK LABORATORY ANALYSES
SEPTEMBER 16, 1976 TWQB INTENSIVE MONITORING SURVEY

Station Location	BOD_5 (mg/l)	NH_3 (mg/l)	NO_2 (mg/l)	NO_3 (mg/l)	Total P (mg/l)	Chloro a (mg/l)	TSS (mg/l)	Total Coliform (MPN/100 ml)	Fecal Coliform (MPN/100 ml)
FM 528	4	3.50	0.13	0.78	3.08	24.1	14	4,200	40
Friendswood Link Road	3	3.50	0.17	1.45	2.37	28.7	24	9,000	400
FM 2351	4	1.50	0.21	1.75	2.88	10.1	20	13,000	100
SH 35	1	0.01	0.02	0.01	2.37	12.2	24	5,000	200
FM 518	<1	0.02	<0.01	0.01	0.05	1.5	32	9,000	10

ATTACHMENT E

EXISTING WASTE LOADS ON CLEAR CREEK

		WCO No.	River[a] Mile		Flow[b] (MGD)	BOD_5[b] (mg/l)	NH_3[c] (mg/l)	BOD_5 (#/day)	L_p (#/day)	N_p (#/day)	Total (#/day)
A	Houston Freight Fwdg. Co.	01796.01	42.7								
				Existing	No Discharge Permit.		----	---	---	---	---
				Permitted	No Discharge Permit.		----	---	---	---	---
B	Intercoastal Chemical Co.	01571.01	22.7 (0.7)								
				Existing	No Discharge Permit.		----	---	---	---	---
				Permitted	No Discharge Permit.		----	---	---	---	---
C	Lowe Chemical Company	00951.01	22.7 (0.6)								
				Existing	0.228	5.6	1.0	11	16	9	25
				Permitted	0.300	----	----	15	23	---	---
D	Retzloff Chemical Co.	01053.01	43.8 (0.3)								
				Existing	No Discharge Permit.		----	---	---	---	---
				Permitted	No Discharge Permit.		----	---	---	---	---
E	Fort Bend ISD	10950.01	45.7 (1.0)								
				Existing	No Discharge Permit.		----	---	---	---	---
				Permitted	No Discharge Permit.		----	---	---	---	---
F1	Friendswood #1	10175.01	20.1								
				Existing	0.250	18.6	10.4	39	58	99	157
				Permitted	0.070	20.0	----	12	18	---	---
F2	Friendswood #2	10175.02	16.4 (0.1)								
				Existing	0.829	17.3	12.6	120	179	398	577
				Permitted	0.750	20.0	----	125	188	---	---

		WCO No.	River[a] Mile		Flow[b] (MGD)	BOD_5[b] (mg/l)	NH_3[c] (mg/l)	BOD_5 (#/day)	L_o (#/day)	N_o (#/day)	Total (#/day)
J	Harris Co. Clear Woods ID	10858.01	19.8								
				Existing	0.248	4.7	5.6	10	15	53	68
				Permitted	0.500	20.0	----	83	125	---	---
K	Heatran, Inc.	11631.01	43.8 (0.4)								
				Existing	0.001	10.0	24.6	<1	<1	1	1
				Permitted	0.009	5.0	5.0	<1	1	2	3
L	Houston-Gulf Meadows	10495.20	33.6 (0.6)								
				Existing	0.790	8.1	12.8	53	80	385	465
				Permitted	1.000	5.0	5.0	42	63	191	254
M	Houston-Sagemont	10495.75	21.9 (4.0)								
				Existing	1.650	6.9	2.5	95	142	157	299
				Permitted	2.000	5.0	5.0	83	125	381	506
N	Houston-Southeast	10495.79	22.7 (4.0)								
				Existing	1.160	4.2	0.1	41	61	4	65
				Permitted	3.000	5.0	5.0	125	188	572	760
P2	Pearland #2	10134.02	31.0								
				Existing	0.869	6.0	14.4	43	65	477	542
				Permitted	1.000	20.0	----	167	250	---	---
P3	Pearland #3	10134.03	25.7								
				Existing	0.599	5.8	18.4	29	43	420	463
				Permitted	0.500	20.0	----	83	125	---	---
P4	Pearland #4	10134.04	33.0								
				Existing	0.091	5.0	0.2	4	6	1	7
				Permitted	0.250	20.0	----	42	63	---	---

		WCO No.	River Mile[a]		Flow[b] (MGD)	BOD_5[b] (mg/l)	NH_3[c] (mg/l)	BOD_5 (#/day)	L_o (#/day)	N_o (#/day)	Total (#/day)
Q	Pearland ISD	11367.01	36.1 (1.0)	Existing	Not constructed yet.		----	---	---	---	---
				Permitted	0.009	5.0	5.0	---	---	---	---

[a] Parentheses indicate river mile up the tributary

[b] Based on average TWQB self-reporting data from January 1976-September 1976.

[c] Based on return flow data and field measurements.

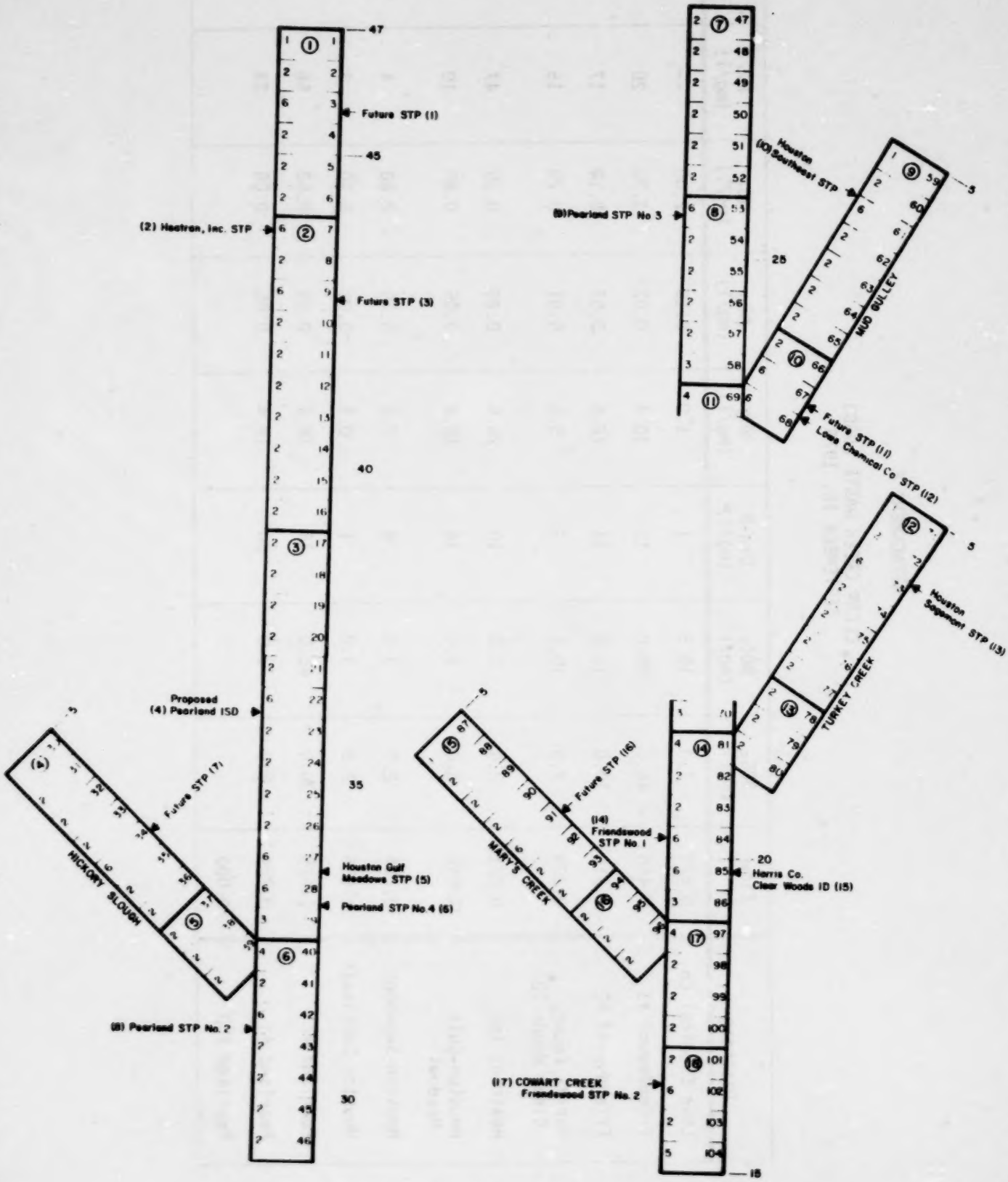
ATTACHMENT F

CLEAR CREEK WASTE LOADS
SEPTEMBER 16, 1976

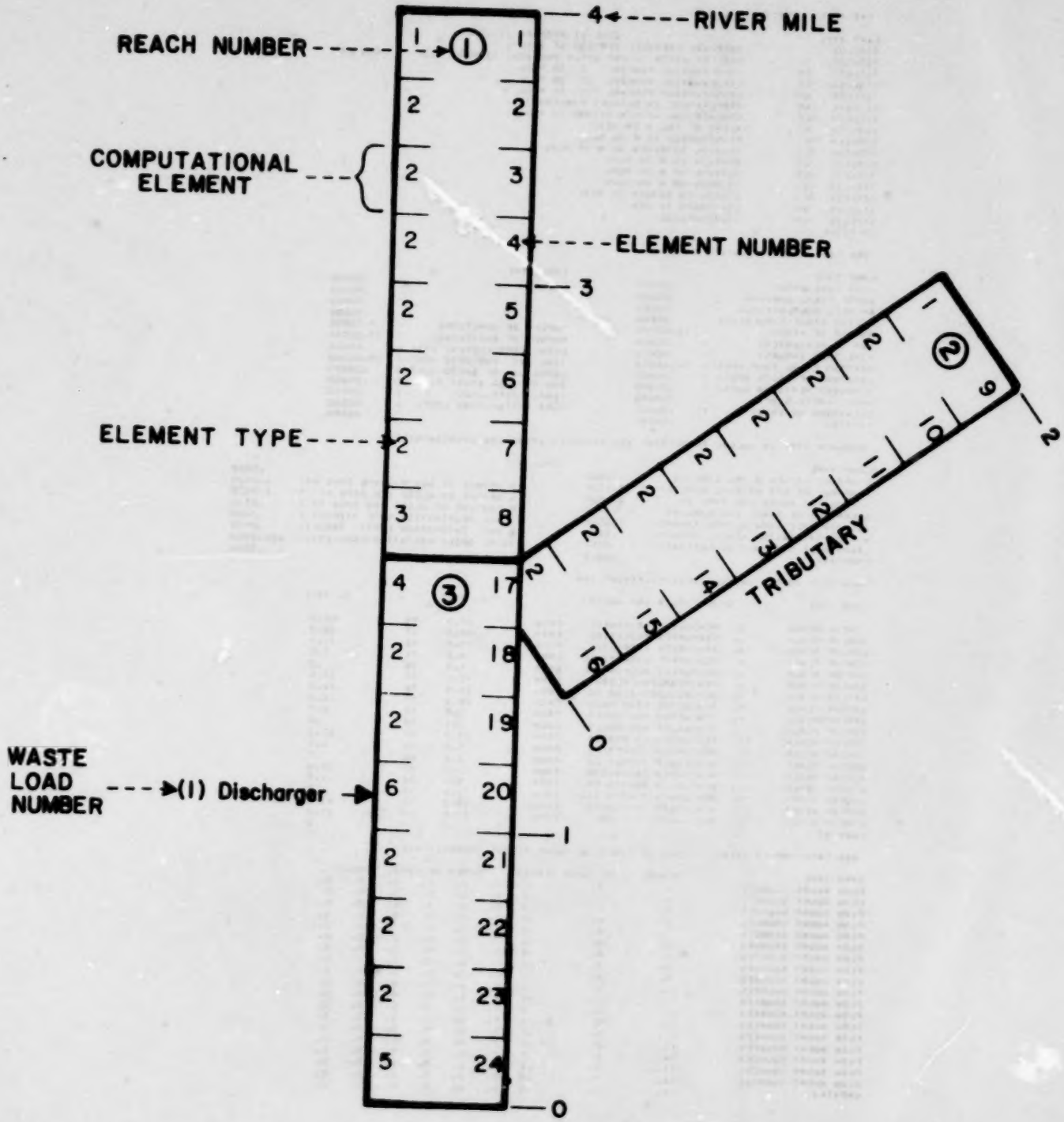
Discharger	Flow (cfs)	BOD_5 (mg/l)	BOD_u (mg/l)	Org-N (mg/l)	NH_3 (mg/l)	NO_2 (mg/l)	NO_3 (mg/l)	TSS (mg/l)	Total P (mg/l)
Lowe Chemical Co.	0.427	7.0	10.5	1	1.0	0.10	2.00	--	------
Friendswood #1	0.450	46.7	70.0	12	10.4	0.02	3.70	20	5.12
Friendswood #2	1.210	10.0	15.0	14	12.6	0.07	0.10	17	7.70
Harris County Clear Woods ID	0.309	7.0	10.5	7	5.6	0.01	0.20	15	3.60
Heatran, Inc.	0.001	2.0	3.0	10	24.6	0.20	0.30	47	4.29
Houston-Gulf Meadows	1.019	6.0	9.0	14	12.8	0.06	0.80	10	1.022
Houston-Sagemont	3.164	2.0	3.0	4	2.5	0.20	2.80	4	4.10
Houston Southeast	1.856	2.0	3.0	1	0.1	0.01	6.20	3	0.39
Pearland #2	1.525	30.0	45.0	16	14.4	0.09	0.03	58	6.34
Pearland #3	0.729	2.0	3.0	20	18.4	0.05	0.05	23	7.85
Pearland ISD	0.000								

ATTACHMENT G-1

CLEAR CREEK SCHEMATIC



ATTACHMENT G-2
SCHEMATIC EXPLANATION



ATTACHMENT H

CLEAR CREEK ABOVE TIDAL
QUAL-II MODEL INPUT

```
*** (PROBLEM TITLES) ***

CARD TYPE                                  QUAL-II PROGRAM TITLES
TITLE01                 THOR/UNL EXPANDED VERSION OF QUAL-I
TITLE02                 NAME OF BASIN -CLEAR CREEK NONTIDAL SEGMENT 1307     RUN 937
TITLE03   NO            CONSERVATIVE MINERAL   I  IN MG/L
TITLE04   NO            CONSERVATIVE MINERAL  II  IN MG/L
TITLE05   NO            CONSERVATIVE MINERAL III  IN MG/L
TITLE06   NO            TEMPERATURE IN DEGREES FAHRENHEIT
TITLE07   YES           BIOCHEMICAL OXYGEN DEMAND IN MG/L
TITLE08   NO            ALGAE AS CHL A IN UG/L
TITLE09   YES           PHOSPHOROUS AS P IN MG/L
TITLE10   YES           ORGANIC NITROGEN AS N IN MG/L
TITLE11   YES           AMMONIA AS N IN MG/L
TITLE12   YES           NITRITE AS N IN MG/L
TITLE13   YES           NITRATE AS N IN MG/L
TITLE14   YES           DISSOLVED OXYGEN IN MG/L
TITLE15   NO            COLIFORMS AS PPM
TITLE16   NO            RADIONUCLIDE
ENDTITLE

*** (DATA TYPE 1 (CONTROL DATA)) ***

CARD TYPE                                          CARD TYPE
LIST DATA INPUT                .00000                                        .00000
WRITE FINAL SUMMARY            .00000                                        .00000
NO FLOW AUGMENTATION           .00000                                        .00000
STEADY STATE SIMULATION        .00000                                        .00000
NUMBER OF REACHES          :  18.00000     NUMBER OF JUNCTIONS       :   9.00000
NUM OF HEADWATERS          :   5.00000     NUMBER OF WASTELOADS      :  17.00000
TIME STEP (HOURS)          :    .00000     LNTH. COMP ELEMENT (MI)   :    .50000
MAXIMUM ROUTE TIME (HRS)   :  36.00000     TIME INC. FOR RPT2 (HRS)  :  30.00000
LATITUDE OF BASIN (DEG)    :    .00000     LONGITUDE OF BASIN (DEG)  :    .00000
STANDARD MERIDIAN (DEG)    :    .00000     DAY OF YEAR START TIME    :    .00000
EVAP. COEFF.,(DEG)         :    .00000     EVAP. COEFF.,(DEG)        :    .00000
ELEVATION OF BASIN         :    .00000     DUST ATTENUATION COEF.    :    .00000
ENDATA1                         .00000                                        .00000

***(DATA TYPE 1A (ALGAE PRODUCTION AND NITROGEN OXIDATION CONSTANTS)***

CARD TYPE                                          CARD TYPE
O UPTAKE BY CHL A (MG O/MG A)  :     .0000                                     .0000
O UPTAKE BY NH3 OXIDIZING O/MG N):  3.4300     O UPTAKE BY NO2 OXIDIZING O/MG N):  1.1400
O PROD. BY ALGAE (MG O/MG A)   :    1.6000     O UPTAKE BY ALGAE (MG O/MG A)  :  1.9500
N CONTENT OF ALGAE (MG N/MG A) :     .0850     P CONTENT OF ALGAE (MG P/MG A) :   .0150
ALG PER SPEC GROWTH RATE(1/DAY):    2.0000     ALGAE RESPIRATION RATE (1/DAY) :   .1000
N HALF SATURATION CONST. (MG/L):     .1000     P HALF SATURATION CONST. (MG/L):   .0000
LIGHT HALF SAT CONST(LANGLEY/MIN):   .0500     TOTAL DAILY RADIATION(LANGLEYS):  600.0000
ENDATA1A                             .0000                                        .0000

*** DATA TYPE 2 (REACH IDENTIFICATION) ***

CARD TYPE          REACH OPTN AND IDENT                 M. MILE              M. MILE

STREAM REACH     1.  REACH:CLEAR CR SOURCE    FROM        47.0    TO         44.0
STREAM REACH     2.  REACH:UPPER PROOF SIDE   FROM        44.0    TO         39.0
STREAM REACH     3.  REACH:LOWER PROOF SIDE   FROM        39.0    TO         32.5
STREAM REACH     4.  REACH:UPPER HICKORY SL   FROM         5.0    TO          1.5
STREAM REACH     5.  REACH:LOWER HICKORY SL   FROM         1.5    TO           .0
STREAM REACH     6.  REACH:FAIRLAND REGION    FROM        32.5    TO         29.0
STREAM REACH     7.  REACH:COUNTRY CLUB RD    FROM        29.0    TO         26.0
STREAM REACH     8.  REACH:DIXIE FARM ROAD    FROM        26.0    TO         23.0
STREAM REACH     9.  REACH:UPPER MUD GULLY    FROM         5.0    TO          1.5
STREAM REACH    10.  REACH:LOWER MUD GULLY    FROM         1.5    TO           .0
STREAM REACH    11.  REACH:GILFILLO REGION    FROM        23.0    TO         22.0
STREAM REACH    12.  REACH:UPPER TURKEY CR    FROM         5.0    TO          1.5
STREAM REACH    13.  REACH:LOWER TURKEY CR    FROM         1.5    TO           .0
STREAM REACH    14.  REACH:UPPER SANDSWOOD    FROM        22.0    TO         19.0
STREAM REACH    15.  REACH:UPPER MARY'S CR    FROM         5.0    TO          1.5
STREAM REACH    16.  REACH:LOWER MARY'S CR    FROM         1.5    TO           .0
STREAM REACH    17.  REACH:LOWER SANDSWOOD    FROM        19.0    TO         17.0
STREAM REACH    18.  REACH:LOWER FM 528       FROM        17.0    TO         15.0
ENDATA2          0.                                         .0                   .0

*** DATA TYPE 3 (TARGET LEVEL DO AND FLOW AUGMENTATION SOURCES) ***

CARD TYPE                 REACH  AVAIL MGD  TARGET    ORDER OF AVAIL SOURCES
FLOW AUGMT SOURCES         1.       0.        .0    0.   0.   0.   0.   0.   0.
FLOW AUGMT SOURCES         2.       0.        .0    0.   0.   0.   0.   0.   0.
FLOW AUGMT SOURCES         3.       0.        .0    0.   0.   0.   0.   0.   0.
FLOW AUGMT SOURCES         4.       0.        .0    0.   0.   0.   0.   0.   0.
FLOW AUGMT SOURCES         5.       0.        .0    0.   0.   0.   0.   0.   0.
FLOW AUGMT SOURCES         6.       0.        .0    0.   0.   0.   0.   0.   0.
FLOW AUGMT SOURCES         7.       0.        .0    0.   0.   0.   0.   0.   0.
FLOW AUGMT SOURCES         8.       0.        .0    0.   0.   0.   0.   0.   0.
FLOW AUGMT SOURCES         9.       0.        .0    0.   0.   0.   0.   0.   0.
FLOW AUGMT SOURCES        10.       0.        .0    0.   0.   0.   0.   0.   0.
FLOW AUGMT SOURCES        11.       0.        .0    0.   0.   0.   0.   0.   0.
FLOW AUGMT SOURCES        12.       0.        .0    0.   0.   0.   0.   0.   0.
FLOW AUGMT SOURCES        13.       0.        .0    0.   0.   0.   0.   0.   0.
FLOW AUGMT SOURCES        14.       0.        .0    0.   0.   0.   0.   0.   0.
FLOW AUGMT SOURCES        15.       0.        .0    0.   0.   0.   0.   0.   0.
FLOW AUGMT SOURCES        16.       0.        .0    0.   0.   0.   0.   0.   0.
FLOW AUGMT SOURCES        17.       0.        .0    0.   0.   0.   0.   0.   0.
FLOW AUGMT SOURCES        18.       0.        .0    0.   0.   0.   0.   0.   0.
ENDATA3                    0.       0.        .0    0.   0.   0.   0.   0.   0.
```

*** DATA TYPE 4 (COMPUTATIONAL REACH FLAG FIELD) ***

LAND TYPE	REACH	ELEMENTS/REACH	COMPUTATIONAL FLAGS
FLAG FIELD	1.	1.	1.....2.2....
FLAG FIELD	2.	16.	1.....2.2.2.2.2.2.2.2.
FLAG FIELD	3.	13.	2.2.2.2.2.2.2.2.2.2.2.3.
FLAG FIELD	4.	7.	1.2.2.2.2.2.2.
FLAG FIELD	5.	3.	2.2.2.
FLAG FIELD	6.	7.	1.....2.2.2.2.
FLAG FIELD	7.	6.	2.2.2.2....2.
FLAG FIELD	8.	6.	1.....3.
FLAG FIELD	9.	7.	1.2.2.2.2.2.2.2.
FLAG FIELD	10.	4.	2.2.2.
FLAG FIELD	11.	2.	1.1.
FLAG FIELD	12.	7.	1.2.2.2.2.2.2.
FLAG FIELD	13.	5.	2.2.2.
FLAG FIELD	14.	6.	1.2.2.2.2.2.3.
FLAG FIELD	15.	7.	1.2.2.2.2.2.2.
FLAG FIELD	16.	3.	2.2.2.
FLAG FIELD	17.	4.	1.1.2.2.
FLAG FIELD	18.	4.	2.2.2.2.
TERMINATOR	0.	0.	

*** DATA TYPE 5 (MANNING COEFFICIENTS FOR DETERMINING VELOCITY AND DEPTH) ***

LAND TYPE	REACH	COEFFOR	EXPOBV	COEFFON	EXPOBN	CHANN
HYDRAULICS	1.	.0700000	.500	2.000	.500	.035
HYDRAULICS	2.	.0700000	.500	2.000	.500	.035
HYDRAULICS	3.	.0700000	.500	2.000	.500	.035
HYDRAULICS	4.	.0700000	.500	2.000	.500	.035
HYDRAULICS	5.	.0700000	.500	2.000	.500	.035
HYDRAULICS	6.	.0700000	.500	1.000	.500	.035
HYDRAULICS	7.	.0700000	.500	1.000	.500	.035
HYDRAULICS	8.	.0700000	.500	1.000	.500	.035
HYDRAULICS	9.	.0700000	.500	1.500	.500	.035
HYDRAULICS	10.	.0700000	.500	1.500	.500	.035
HYDRAULICS	11.	.0700000	.500	1.500	.500	.035
HYDRAULICS	12.	.0700000	.500	1.500	.500	.035
HYDRAULICS	13.	.0700000	.500	1.500	.500	.035
HYDRAULICS	14.	.0500000	.500	1.000	.500	.035
HYDRAULICS	15.	.0700000	.500	2.000	.500	.035
HYDRAULICS	16.	.0700000	.500	2.000	.500	.035
HYDRAULICS	17.	.0700000	.500	5.000	.100	.035
HYDRAULICS	18.	.0300000	.500	4.000	.100	.035
TERMINATOR	...	.0000000	.000	.000	.000	.000

*** DATA TYPE 6 (REACTION COEFFICIENTS FOR DEOXYGENATION AND REAERATION) ***

LAND TYPE	REACH	K1	K3	K2OPT	K2	COEFK2	EXPOK2
REACT COEF	1.	.00	.00	1.	.00	.000	.000
REACT COEF	2.	.00	.00	1.	.00	.000	.000
REACT COEF	3.	.15	.00	3.	.00	.000	.000
REACT COEF	4.	.15	.00	3.	.00	.000	.000
REACT COEF	5.	.15	.00	3.	.00	.000	.000
REACT COEF	6.	.15	.00	3.	.00	.000	.000
REACT COEF	7.	.15	.00	3.	.00	.000	.000
REACT COEF	8.	.15	.00	3.	.00	.000	.000
REACT COEF	9.	.15	.00	3.	.00	.000	.000
REACT COEF	10.	.15	.00	3.	.00	.000	.000
REACT COEF	11.	.15	.00	3.	.00	.000	.000
REACT COEF	12.	.15	.00	3.	.00	.000	.000
REACT COEF	13.	.15	.00	3.	.00	.000	.000
REACT COEF	14.	.15	.00	3.	.00	.000	.000
REACT COEF	15.	.15	.00	3.	.00	.000	.000
REACT COEF	16.	.15	.00	3.	.00	.000	.000
REACT COEF	17.	.20	.15	3.	.00	.000	.000
REACT COEF	18.	.20	.15	3.	.00	.000	.000
TERMINATOR	0.	.00	.00	0.	.00	.000	.000

*** DATA TYPE 7A (ALGAL, NITROGEN, AND PHOSPHOROUS CONSTANTS) ***

LAND TYPE	REACH	ALPHA0	ALGSET	CKNH3	CKNO2	SNH4	SPO4	ORG-N
ALGAL, N AND P COEF	1.	75.0	.00	.00	.00	.00	.00	.00
ALGAL, N AND P COEF	2.	75.0	.00	.00	.00	.00	.00	.00
ALGAL, N AND P COEF	3.	75.0	.10	.20	1.50	.10	.10	.04
ALGAL, N AND P COEF	4.	75.0	.00	.20	1.50	.00	.00	.04
ALGAL, N AND P COEF	5.	75.0	.00	.20	1.50	.00	.00	.04
ALGAL, N AND P COEF	6.	75.0	.00	.20	1.50	.00	.00	.04
ALGAL, N AND P COEF	7.	75.0	.00	.20	1.50	.00	.00	.04
ALGAL, N AND P COEF	8.	75.0	.10	.20	1.50	.00	.00	.04
ALGAL, N AND P COEF	9.	75.0	.00	.20	1.50	.00	.00	.04
ALGAL, N AND P COEF	10.	75.0	.10	.20	1.50	.00	.00	.04
ALGAL, N AND P COEF	11.	75.0	.00	.20	1.50	.00	.00	.04
ALGAL, N AND P COEF	12.	75.0	.10	.20	1.50	.00	.00	.04
ALGAL, N AND P COEF	13.	75.0	.00	.20	1.50	.00	.00	.04
ALGAL, N AND P COEF	14.	75.0	.00	.20	1.50	.00	.00	.04
ALGAL, N AND P COEF	15.	75.0	.00	.20	1.50	.00	.00	.04
ALGAL, N AND P COEF	16.	75.0	.00	.20	1.50	.00	.00	.04
ALGAL, N AND P COEF	17.	75.0	.00	.20	1.50	.00	.00	.04
ALGAL, N AND P COEF	18.	75.0	.00	.20	1.50	.00	.00	.04
TERMINATOR	0.	.0	.00	.00	.00	.00	.00	.00

$$$ DATA TYPE 6B (OTHER COEFFICIENTS) $$$

CARD TYPE	REACH	CM4	CM5	EXCOEF	CM6
OTHER COEFFICIENTS	1.	.00	.00	.10	.00
OTHER COEFFICIENTS	2.	.00	.00	.10	.00
OTHER COEFFICIENTS	3.	500.00	.10	.10	.00
OTHER COEFFICIENTS	4.	500.00	.10	.10	.00
OTHER COEFFICIENTS	5.	500.00	.10	.10	.00
OTHER COEFFICIENTS	6.	500.00	.10	.10	.00
OTHER COEFFICIENTS	7.	500.00	.10	.10	.00
OTHER COEFFICIENTS	8.	500.00	.10	.10	.00
OTHER COEFFICIENTS	9.	500.00	.10	.10	.00
OTHER COEFFICIENTS	10.	500.00	.10	.10	.00
OTHER COEFFICIENTS	11.	500.00	.10	.10	.00
OTHER COEFFICIENTS	12.	500.00	.10	.10	.00
OTHER COEFFICIENTS	13.	500.00	.10	.10	.00
OTHER COEFFICIENTS	14.	500.00	.10	.10	.00
OTHER COEFFICIENTS	15.	500.00	.10	.10	.00
OTHER COEFFICIENTS	16.	500.00	.10	.10	.00
OTHER COEFFICIENTS	17.	700.00	.10	.10	.00
OTHER COEFFICIENTS	18.	700.00	.10	.10	.00
ENDATA6B	0.	.00	.00	.00	.00

$$$ DATA TYPE 7 (INITIAL CONDITIONS) $$$

CARD TYPE	REACH	TEMP	D.O.	BOD	CM-I	CM-II	CM-III
INITIAL CONDITIONS	1.	60.0	.0	.0	.0	.0	.0
INITIAL CONDITIONS	2.	60.0	.0	.0	.0	.0	.0
INITIAL CONDITIONS	3.	60.0	.0	.0	.0	.0	.0
INITIAL CONDITIONS	4.	60.0	.0	.0	.0	.0	.0
INITIAL CONDITIONS	5.	60.0	.0	.0	.0	.0	.0
INITIAL CONDITIONS	6.	60.0	.0	.0	.0	.0	.0
INITIAL CONDITIONS	7.	60.0	.0	.0	.0	.0	.0
INITIAL CONDITIONS	8.	60.0	.0	.0	.0	.0	.0
INITIAL CONDITIONS	9.	60.0	.0	.0	.0	.0	.0
INITIAL CONDITIONS	10.	60.0	.0	.0	.0	.0	.0
INITIAL CONDITIONS	11.	60.0	.0	.0	.0	.0	.0
INITIAL CONDITIONS	12.	60.0	.0	.0	.0	.0	.0
INITIAL CONDITIONS	13.	60.0	.0	.0	.0	.0	.0
INITIAL CONDITIONS	14.	60.0	.0	.0	.0	.0	.0
INITIAL CONDITIONS	15.	60.0	.0	.0	.0	.0	.0
INITIAL CONDITIONS	16.	60.0	.0	.0	.0	.0	.0
INITIAL CONDITIONS	17.	60.0	.0	.0	.0	.0	.0
INITIAL CONDITIONS	18.	60.0	.0	.0	.0	.0	.0
ENDATA7	0.	.0	.0	.0	.0	.0	.0

$$$ DATA TYPE 7A (INITIAL CONDITIONS FOR CHLOROPHYLL A, NITROGEN, PHOSPHOROUS, COLIFORM AND RADIONUCLIDE) $$$

CARD TYPE	REACH	CHLORA	NH3	NO2	NO3	PO4	COLI	RADN	ORG-N
INITIAL COND-2	1.	.0	.00	.00	.00	.00	.0	.00	.00
INITIAL COND-2	2.	.0	.00	.00	.00	.00	.0	.00	.00
INITIAL COND-2	3.	.0	.00	.00	.00	.00	.0	.00	.00
INITIAL COND-2	4.	.0	.00	.00	.00	.00	.0	.00	.00
INITIAL COND-2	5.	.0	.00	.00	.00	.00	.0	.00	.00
INITIAL COND-2	6.	.0	.00	.00	.00	.00	.0	.00	.00
INITIAL COND-2	7.	.0	.00	.00	.00	.00	.0	.00	.00
INITIAL COND-2	8.	.0	.00	.00	.00	.00	.0	.00	.00
INITIAL COND-2	9.	.0	.00	.00	.00	.00	.0	.00	.00
INITIAL COND-2	10.	.0	.00	.00	.00	.00	.0	.00	.00
INITIAL COND-2	11.	.0	.00	.00	.00	.00	.0	.00	.00
INITIAL COND-2	12.	.0	.00	.00	.00	.00	.0	.00	.00
INITIAL COND-2	13.	.0	.00	.00	.00	.00	.0	.00	.00
INITIAL COND-2	14.	.0	.00	.00	.00	.00	.0	.00	.00
INITIAL COND-2	15.	.0	.00	.00	.00	.00	.0	.00	.00
INITIAL COND-2	16.	.0	.00	.00	.00	.00	.0	.00	.00
INITIAL COND-2	17.	.0	.00	.00	.00	.00	.0	.00	.00
INITIAL COND-2	18.	.0	.00	.00	.00	.00	.0	.00	.00
ENDATA7A	0.	.0	.00	.00	.00	.00	.0	.00	.00

$$$ DATA TYPE 8 (RUNOFF CONDITIONS) $$$

CARD TYPE	REACH	Q	TEMP	D.O.	BOD	CM-I	CM-II	CM-III
RUNOFF CONDITIONS	1.	.0	.0	.0	.0	.0	.0	.0
RUNOFF CONDITIONS	2.	.0	.0	.0	.0	.0	.0	.0
RUNOFF CONDITIONS	3.	.0	.0	.0	.0	.0	.0	.0
RUNOFF CONDITIONS	4.	.0	.0	.0	.0	.0	.0	.0
RUNOFF CONDITIONS	5.	.0	.0	.0	.0	.0	.0	.0
RUNOFF CONDITIONS	6.	.0	.0	.0	.0	.0	.0	.0
RUNOFF CONDITIONS	7.	.0	.0	.0	.0	.0	.0	.0
RUNOFF CONDITIONS	8.	.0	.0	.0	.0	.0	.0	.0
RUNOFF CONDITIONS	9.	.0	.0	.0	.0	.0	.0	.0
RUNOFF CONDITIONS	10.	.0	.0	.0	.0	.0	.0	.0
RUNOFF CONDITIONS	11.	.0	.0	.0	.0	.0	.0	.0
RUNOFF CONDITIONS	12.	.0	.0	.0	.0	.0	.0	.0
RUNOFF CONDITIONS	13.	.0	.0	.0	.0	.0	.0	.0
RUNOFF CONDITIONS	14.	.0	.0	.0	.0	.0	.0	.0
RUNOFF CONDITIONS	15.	.0	.0	.0	.0	.0	.0	.0
RUNOFF CONDITIONS	16.	.0	.0	.0	.0	.0	.0	.0
RUNOFF CONDITIONS	17.	.0	.0	.0	.0	.0	.0	.0
RUNOFF CONDITIONS	18.	.0	.0	.0	.0	.0	.0	.0
ENDATA8	0.	.0	.0	.0	.0	.0	.0	.0

*** DATA TYPE 8A (INCREMENTAL FLOW CONDITIONS FOR NITROGEN, PHOSPHORUS, COLIFORM AND RADIONUCLIDES) ***

CARD TYPE	REACH	CHLORA	NH3	NO2	NO3	PO4	COLI	RADN	ORG-N
RUNOFF COND-2	1.	.0	.00	.00	.00	.00	.0	.00	.00
RUNOFF COND-2	2.	.0	.00	.00	.00	.00	.0	.00	.00
RUNOFF COND-2	3.	.0	.00	.00	.00	.00	.0	.00	.00
RUNOFF COND-2	4.	.0	.00	.00	.00	.00	.0	.00	.00
RUNOFF COND-2	5.	.0	.00	.00	.00	.00	.0	.00	.00
RUNOFF COND-2	6.	.0	.00	.00	.00	.00	.1	.00	.00
RUNOFF COND-2	7.	.0	.00	.00	.00	.00	.0	.00	.00
RUNOFF COND-2	8.	.0	.00	.00	.00	.00	.0	.00	.00
RUNOFF COND-2	9.	.0	.00	.00	.00	.00	.0	.00	.00
RUNOFF COND-2	10.	.0	.00	.00	.00	.00	.0	.00	.00
RUNOFF COND-2	11.	.0	.00	.00	.00	.00	.0	.00	.00
RUNOFF COND-2	12.	.0	.00	.00	.00	.00	.0	.00	.00
RUNOFF COND-2	13.	.0	.00	.00	.00	.00	.0	.00	.00
RUNOFF COND-2	14.	.0	.00	.00	.00	.00	.0	.00	.00
RUNOFF COND-2	15.	.0	.00	.00	.00	.00	.0	.00	.00
RUNOFF COND-2	16.	.0	.00	.00	.00	.00	.0	.00	.00
RUNOFF COND-2	17.	.0	.00	.00	.00	.00	.0	.00	.00
RUNOFF COND-2	18.	.0	.00	.00	.00	.00	.0	.00	.00
ENDATA88		.0	.00	.00	.00	.00	.0	.00	.00

*** DATA TYPE 9 (STREAM JUNCTIONS) ***

CARD TYPE	JUNCTION ORDER AND IDENT	UPSTRM	JUNCTION	TRIB
STREAM JUNCTION	1. JNC:HICKORY SLOUGH	29.	40.	39.
STREAM JUNCTION	2. JNC:MUD GULLY	58.	69.	68.
STREAM JUNCTION	3. JNC:TURKEY CREEK	78.	81.	80.
STREAM JUNCTION	4. JNC:MALTY'S CREEK	86.	97.	96.
ENDATA89		0.	0.	0.

*** DATA TYPE 10 (HEADWATER SOURCES) ***

CARD TYPE	HDWATER ORDER AND IDENT	FLOW	TEMP	D.O.	BOD	CM-I	CM-II	CM-III
HEADWATER	1. HDW:CLEAR CR SOURCE	2.4	80.0	6.9	1.5	.0	.0	.0
HEADWATER	2. HDW:HICKORY SLOUGH	.1	80.0	6.0	1.0	.0	.0	.0
HEADWATER	3. HDW:MUD GULLEY	.1	80.0	6.0	1.0	.0	.0	.0
HEADWATER	4. HDW:TURKEY CREEK	.1	80.0	6.0	1.0	.0	.0	.0
HEADWATER	5. HDW:MARVY'S CREEK	.1	80.0	6.0	1.0	.0	.0	.0
ENDATA10	0.	.0	.0	.0	.0	.0	.0	.0

*** DATA TYPE 10A (HEADWATER CONDITIONS FOR CHLOROPHYLL, NITROGEN, PHOSPHOROUS, COLIFORM AND RADIONUCLIDES) ***

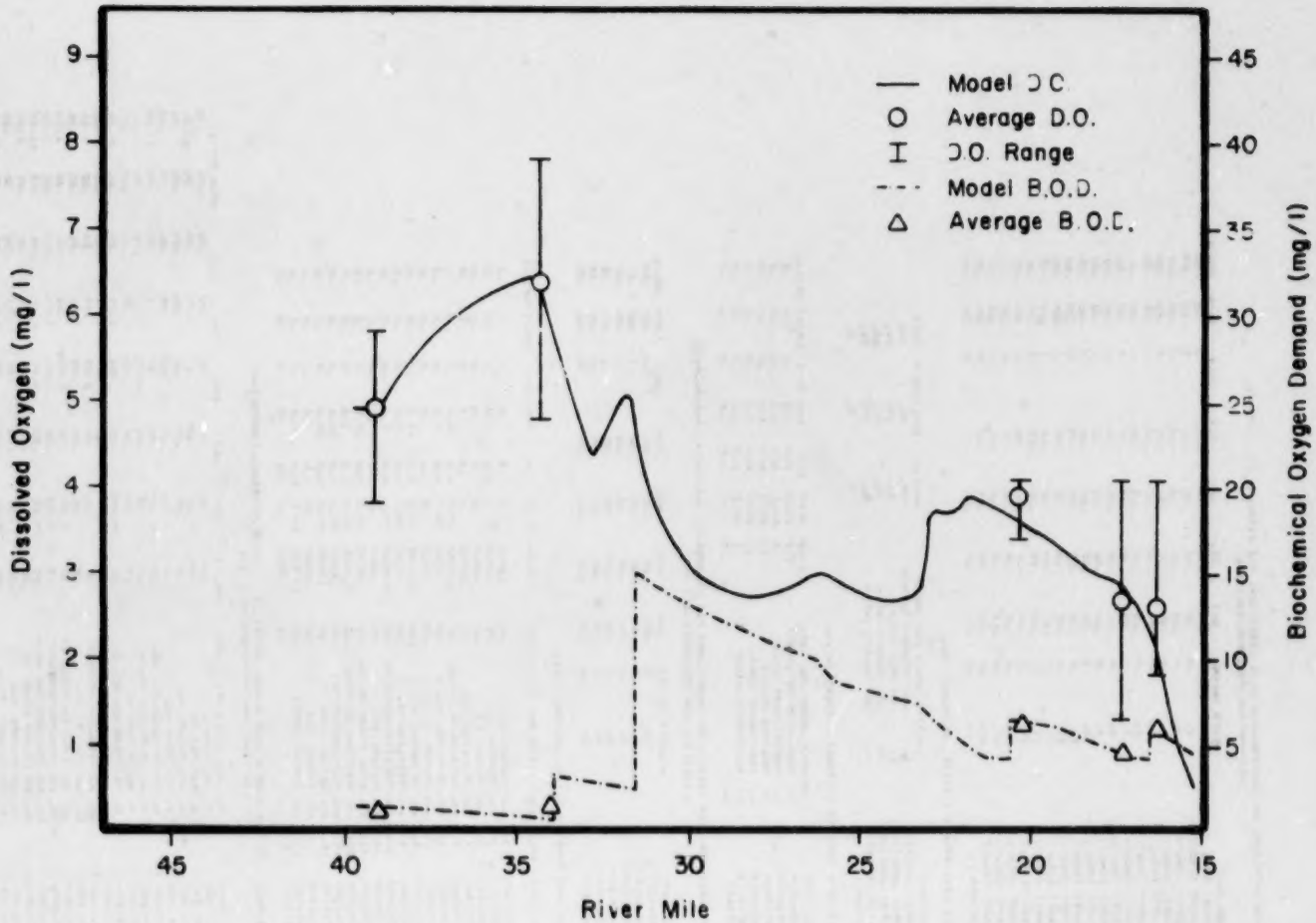
CARD TYPE	HDWATER	CHLORA	NH3	NO2	NO3	PO4	COLI	RADN	ORG-N
HEADWATER-2	1.	.0	.02	.01	.01	.01	.0	.00	.00
HEADWATER-2	2.	.0	.00	.00	.00	.00	.0	.00	.00
HEADWATER-2	3.	.0	.00	.00	.00	.00	.0	.00	.00
HEADWATER-2	4.	.0	.00	.00	.00	.00	.0	.00	.00
HEADWATER-2	5.	.0	.00	.00	.00	.00	.0	.00	.00
ENDATA10A	0.	.0	.00	.00	.00	.00	.0	.00	.00

*** DATA TYPE 11 (WASTE LOADINGS) ***

CARD TYPE	WASTE LOAD ORDER AND IDENT	EFF	FLOW	TEMP	D.O.	BOD	CM-I	CM-II	CM-III
WASTELOAD	1. WSL:FUTURE 01	.00	.0000	.0	.0	.0	.0	.0	.0
WASTELOAD	2. WSL:PEARLAN	.01	.1010	79.0	4.0	1.0	.0	.0	.0
WASTELOAD	3. WSL:FUTURE 03	.00	.0000	.0	.0	.0	.0	.0	.0
WASTELOAD	4. WSL:PEARLAND ISD	.00	.0000	.0	.0	.0	.0	.0	.0
WASTELOAD	5. WSL:HOUSTON-ALF PUGS	.00	1.0100	79.0	6.0	9.0	.0	.0	.0
WASTELOAD	6. WSL:PEARLAND NO. 4	.00	.1700	79.0	4.0	1.0	.0	.0	.0
WASTELOAD	7. WSL:FUTURE 07	.00	.0000	.0	.0	.0	.0	.0	.0
WASTELOAD	8. WSL:PEARLAND NO. 2	.00	1.5250	79.0	4.0	45.0	.0	.0	.0
WASTELOAD	9. WSL:PEARLAND NO. 3	.00	.7290	79.0	4.0	3.0	.0	.0	.0
WASTELOAD	10. WSL:HOUSTON-SOUTHWEST	.00	1.0540	79.0	4.0	3.0	.0	.0	.0
WASTELOAD	11. WSL:FUTURE 011	.00	.0000	.0	.0	.0	.0	.0	.0
WASTELOAD	12. WSL:GLOBE CHEMICAL CO	.00	.4270	79.0	4.0	10.0	.0	.0	.0
WASTELOAD	13. WSL:HOUSTON-SABERMONT	.00	3.1440	79.0	4.0	1.0	.0	.0	.0
WASTELOAD	14. WSL:FRIENDSWOOD NO.1	.00	.4500	79.0	4.0	73.0	.0	.0	.0
WASTELOAD	15. WSL:CLEAR WOODS ID	.00	.3700	79.0	4.0	10.0	.0	.0	.0
WASTELOAD	16. WSL:FUTURE 016	.00	.0000	.0	.0	.0	.0	.0	.0
WASTELOAD	17. WSL:COUGART CREEK	.00	1.2100	79.0	4.0	30.0	.0	.0	.0
ENDATA11	0.	.00	.0000	.0	.0	.0	.0	.0	.0

*** DATA TYPE 11A (WASTE LOAD CHARACTERISTICS - ALGAE, NITROGEN, PHOSPHOROUS, COLIFORMS AND RADIONUCLIDES) ***

CARD TYPE	WASTE LOAD ORDER AND IDENT	CHL. A	NH3	NO2	NO3	PO4	COLI	RADN	ORG-N
WASTELOAD-2	1. WSL:FUTURE 01	.00	.00	.00	.00	.00	.00	.00	.00
WASTELOAD-2	2. WSL:PEARLAND	.00	29.00	.20	.27	3.30	.00	.00	10.00
WASTELOAD-2	3. WSL:FUTURE 03	.00	.00	.00	.00	.00	.00	.00	.00
WASTELOAD-2	4. WSL:PEARLAND ISD	.00	.00	.00	.00	.00	.00	.00	.00
WASTELOAD-2	5. WSL:HOUSTON-ALF PUGS	.00	12.40	.04	.04	.75	.00	.00	15.00
WASTELOAD-2	6. WSL:PEARLAND NO. 4	.00	.15	.01	19.70	9.72	.00	.00	.00
WASTELOAD-2	7. WSL:FUTURE 07	.00	.00	.00	.00	.00	.00	.00	.00
WASTELOAD-2	8. WSL:PEARLAND NO. 2	.00	19.40	.04	.03	2.44	.00	.00	15.00
WASTELOAD-2	9. WSL:PEARLAND NO. 3	.00	18.40	.04	.06	7.46	.00	.00	19.00
WASTELOAD-2	10. WSL:HOUSTON-SOUTHWEST	.00	.10	.01	6.10	.39	.00	.00	1.00
WASTELOAD-2	11. WSL:FUTURE 011	.00	.00	.00	.00	.00	.00	.00	.00
WASTELOAD-2	12. WSL:GLOBE CHEMICAL CO	.00	1.00	.10	2.00	.00	.00	.00	1.00
WASTELOAD-2	13. WSL:HOUSTON-SABERMONT	.00	2.50	.20	2.00	1.41	.00	.00	3.00
WASTELOAD-2	14. WSL:FRIENDSWOOD NO.1	.00	18.40	.02	3.68	4.46	.00	.00	13.00
WASTELOAD-2	15. WSL:CLEAR WOODS ID	.00	5.00	.01	.19	3.59	.00	.00	6.00
WASTELOAD-2	16. WSL:FUTURE 016	.00	.00	.00	.00	.00	.00	.00	.00
WASTELOAD-2	17. WSL:COUGART CREEK	.00	12.40	.07	.04	7.11	.00	.00	13.00
ENDATA11A		.00	.00	.00	.00	.00	.000		



ATTACHMENT J: CALIBRATION — SEPT. 16, 1976 SURVEY RESPONSE CURVES FOR CLEAR CREEK (ABOVE TIDAL) MODEL

ATTACHMENT K

WASTEWATER TREATMENT PLANT DISCHARGE DESCRIPTION

Alternative Number: _____

Plant Name: _____

Waste Control Order Number: _____

Segment Name & Number: _____

Location:

Comments:

	Existing Discharge (12 Mos. Avg.)	Existing W.C.O. Limits	Proposed Discharge
Q (MGD)			
a) 30 day average	_____	_____	_____
b) 7 day average	_____	_____	_____
BOD_5 (mg/l)			
a) 30 day average	_____	_____	_____
b) 7 day average	_____	_____	_____
NH_3-N (mg/l)			
a) 30 day average	_____	_____	_____
b) 7 day average	_____	_____	_____
Fecal Coliform (#/100 ml.)	_____	_____	_____
Effluent D.O. (mg/l)	_____	_____	_____
Effluent Temp. (°C)	_____	_____	_____
Chlorine Residual (mg/l)	_____	_____	_____

WATER QUALITY MODELING

FOR THE

208 DESIGNATED PLANNING AREAS

HOUSTON AREA STEADY-STATE MODELING REPORTS

SAN JACINTO RIVER (TIDAL) - SEGMENT 1001

Prepared by:

Administrative Operations Division
Texas Water Quality Board
Austin, Texas

for the

Houston-Galveston Area Council

and the

U. S. Environmental Protection Agency

The preparation of this report was financed through planning grants from the U. S. Environmental Protection Agency through the Houston-Galveston Area Council.

May, 1977

TAPLE OF CONTENTS

		PAGE
I.	INTRODUCTION	1
II.	DESCRIPTION OF STUDY AREA	1
III.	PRESENTATION OF DATA	2
	A) Historical Water Quality	2
	B) Present Water Quality	2
	C) Present Waste Loadings	3
	D) Hydrological Data	3
IV.	MATHEMATICAL MODEL FORMULATION	4
	A) Advantages	4
	B) Disadvantages	5
V.	MATHEMATICAL MODELING OF WATER QUALITY	5
	A) General	5
	B) Segmentation	6
	C) Hydraulics	6
	D) Atmospheric Reaeration	8
	E) Carbonaceous Demands	8
	F) Nitrogenous Demands	8
	G) Benthal Demands	9
	H) Photosynthesis/Respiration	9
	I) Coliforms	9
	J) Temperature Correction Factors	10
VI.	MODEL ANALYSIS	10
VII.	SENSITIVITY ANALYSIS	11
VIII.	RECOMMENDATIONS FOR MODEL USE	12
IX.	SUMMARY	14

LIST OF ATTACHMENTS

		PAGE
A	HOUSTON AREA - Segment Location Map	A-1
B-1	SAN JACINTO RIVER TIDAL - Segment 1001	B-1
B-2	MAP LEGEND - San Jacinto River	B-2
C	TWQB STREAM MONITORING DATA - San Jacinto River . . .	C-1
D-1	SAN JACINTO RIVER DIURNAL FIELD MEASUREMENTS January 13, 1976 City of Houston Survey	D-1
D-2	SAN JACINTO RIVER LABORATORY ANALYSES January 13, 1976 City of Houston Survey	D-2
D-3	SAN JACINTO RIVER DIURNAL COLIFORM ANALYSES January 13, 1976 City of Houston Survey	D-3
	EXISTING WASTE LOADS ON SAN JACINTO RIVER	E-1
F	SAN JACINTO RIVER WASTE LOADS January 13, 1976	F-1
G-1	SAN JACINTO RIVER SCHEMATIC	G-1
G-2	SCHEMATIC EXPLANATION	G-2
H	SAN JACINTO RIVER - AUTO-QUAL Model Input	H-1
J-1	CALIBRATION - Response Curves for San Jacinto River (Tidal) Model January 13, 1976 Survey	J-1
K	WASTEWATER TREATMENT PLANT DISCHARGE DESCRIPTION . .	K-1

I. INTRODUCTION

This report has been prepared in accordance with an agreement between the Texas Water Quality Board and the Houston-Galveston Area Council covering the improvement of steady-state mathematical models of stream water quality for the Houston "208" area. As required in Task 2.63, the purpose of the report is to incorporate data obtained through Task 2.62 into a steady-state stream model which can predict water quality along the tidal portion of the San Jacinto River (Segment 1001). The model used is a dispersive steady-state model, AUTO-QUAL (AUTOSS), developed by the Environmental Protection Agency, Washington, D.C. in March 1973.

A general description of the study area along with past and present water quality conditions are discussed. The major waste dischargers are summarized. The choice of model and the significant physical and chemical parameters needed as input into the model are presented. The results of the model calibration/verification attempts are presented and discussed. An analysis to determine the sensitivity of the model parameters is included. A final section discusses the actual use of the model.

II. DESCRIPTION OF STUDY AREA

The study area consists of that portion of the San Jacinto River from 200 yards below the IH 10 bridge to the Lake Houston Dam (Segment 1001). It is located 16 miles northeast of downtown Houston (see Attachment A). Major tributaries to the segment are Jackson Bayou and Granite Spring Creek.

The drainage area of the segment is not heavily industrialized, and there are no major farming activities in this area. However, commercial sand dredging occurs in this segment and is of significant concern to the citizens who reside along the segment or use it for recreation. There are several residential communities along the segment, and it is used for contact recreation. One industrial operation, eight municipal facilities, and one combined industrial-municipal facility presently discharge along the San Jacinto River. One industrial operation holds a no discharge permit. The Houston Ship Channel joins the San Jacinto River just below the segment boundary and greatly influences the quality in the segment by tidal interchange.

III. PRESENTATION OF DATA

A) Historical Water Quality

The water quality of this segment is influenced by the tidal interchange action from the Houston Ship Channel and point source dischargers located along the segment. The TWQB maintains two water quality monitoring stations (see Attachment B) within the segment at IH 10 (Station 1001.01) and at US 90 (Station 1001.02).

Dissolved oxygen and fecal coliform standards for Segment 1001 are 4.0 mg/l and 200/100 ml, respectively, at a depth of one foot. Water quality data gathered at these stations from October 1971 through August 1976 (Attachment C) indicate that the segment has had problems with low dissolved oxygen levels and high fecal coliform counts.

Since 1971, two violations of the dissolved oxygen standard have occurred at IH 10. On June 19, 1972 and August 8, 1972, dissolved oxygen concentrations of 3.0 and 3.6 mg/l, respectively, were recorded during critical conditions of high temperature (over 80°F) and incoming tides. During the same period these two samples were taken, the dissolved oxygen at US 90 was at all times above the 4.0 mg/l standard.

Low dissolved oxygen values at IH 10 have also been observed at lower depths where the standards do not apply. Three samples in 1972 and one in 1974 were observed to fall below 2.0 mg/l. One sample in 1974, two samples in 1975, and two samples in 1976 were observed to fall between 2 and 3 mg/l. These values were observed at water temperatures above 80°F.

The fecal coliform standard was exceeded in two out of three samples in 1972, four out of five samples in 1973, and one out of five samples in 1974 at IH 10. At US 90, the standard was exceeded in two out of two samples in 1972 and one out of four samples in 1973.

B) Present Water Quality

The City of Houston conducted a water quality survey on the San Jacinto River January 13, 1976. This survey was designed to provide data for model calibration. Sampling stations were located at IH 10, Wallisville Road, US 90, and Magnolia Gardens as shown in Attachment B.

Field measurements were taken at a depth of 1.0 foot below the surface and 1.0 foot above the bottom at approximately three-hour intervals for twenty-four hours. The field parameters include dissolved oxygen, temperature, pH, and conductivity. Composite samples over the twenty-four hour period were also taken at each station for laboratory analysis. The parameters measured in the laboratory include biochemical oxygen demand, organic nitrogen, ammonia nitrogen, nitrite nitrogen, nitrate nitrogen, total phosphorus, chlorophyll a, total suspended solids, and total dissolved solids. Total coliform and fecal coliform were also determined. A summary of the diurnal field measurements and the laboratory analyses is contained in Attachment D.

Analysis of the data indicates that the concentration of BOD and NH_3 increases in the downstream direction. This reflects the effect of the Houston Ship Channel on the San Jacinto River. Waste disperses up the San Jacinto River from its confluence with the Houston Ship Channel. A slight dissolved oxygen sag is seen approximately seven miles upstream of the Houston Ship Channel at Wallisville Road. The low instream temperature of 14°C (57°F) prevented the sag from being very noticeable. During the summer, the dissolved oxygen sag would more likely be much greater.

C) Present Waste Loadings

The average waste loadings during the period of January 1976 to September 1976 for discharges along the San Jacinto River are presented in Attachment E. Attachment F summarizes the waste loadings during the January 13, 1976 survey. The waste loadings are based on the January 13, 1976 survey, TWQB self-reporting data, and TWQB return flow data.

D) Hydrological Data

The San Jacinto River below Lake Houston is tidally influenced. A tidal gaging station is maintained at U.S. Highway 90 by the United States Geological Survey. The difference between high and low tide during the January survey was 0.7 feet.

The headwater inflow to the San Jacinto River was estimated to be 500 cfs from the Lake Houston elevation and spillway rating curve at the dam. The Houston Ship Channel was estimated to be flowing at about 700 cfs based on USGS stations and return flow data. Because extended periods of time occur when no water is flowing over the Lake Houston

spillway, the 7 day-2 year low flow for the San Jacinto River can be considered to be 0.

IV. MATHEMATICAL MODEL FORMULATION

The AUTO-QUAL model (AUTOSS) was chosen for use on the San Jacinto River because of its ability to model a dispersive system and because it included nitrogenous biochemical oxygen demand (NBOD). Previously, the ESTPOL-I model had been used on the San Jacinto River, but it failed to account for the NBOD.

AUTOSS is a longitudinal steady-state model designed specifically for water bodies where widths are small relative to their length and whose net circulation patterns are essentially unidirectional. The river is represented mathematically by the "channel-junction" or "link-node" method. This method consists of dividing the natural system into a finite number of sections each with a finite volume of water. These finite volumes of water called junctions are considered uniform in property with the average concentration represented as a point value at the center of the junction. The transfer of properties from one junction to the next is performed computationally by the channels. The channel is an interface between two junctions and has no water properties associated with it. Computationally, the channel is treated as a uniform, rectangular channel between junction midpoints.

The quality solutions in AUTOSS are based on mass balance equations at each junctions. Constituents capable of being modeled are CBOD, NBOD, DO, and conservative materials. The basic solution technique used is called the "Gauss-Seidel Iterative" method with a relaxation factor added to increase or decrease the rate of change. A schematic diagram on the San Jacinto model is shown in Attachment G.

<u>Advantages</u>

1) Descriptive data such as depth, temperature, decay rates, etc. are read into the model at different locations on the stream and intermediate values are interpolated within the program. For example, the depth can be variable from one foot to three feet from the head of the stream to the mouth. The program will assign intermediate values by a linear interpolation.

2) Multiple runs are possible. You simple re-read new input data.

3) The length of the computational element is easily changed without having to change a flag field as in a QUAL-II model.

4) Waste loads can be entered at any point by river mile. There is no flag field to be changed.

5) The input data is in a very similar form to that required by AUTOQD, the quasi-dynamic model.

6) The program can handle streams and estuaries or a combined stream/estuary.

7) It is possible to fix the concentration of a pollutant at a known value at any location. This naturally changes the solution profile.

Disadvantages

1) The program will sometimes not converge at all, if the waste loads are very small or if the assumed initial concentrations are not good. The program may show convergence to a waste profile which is not actually true. Both of these cases can generally be recognized and corrected.

2) The line printer graphs of waste and DO profiles produced by the program are not as useful as the QUAL-II type plots.

3) The program has not been used as much as the QUAL-II program, and therefore may not be recognized as readily by others in the profession.

V. MATHEMATICAL MODELING OF WATER QUALITY

A) General

Dissolved oxygen modeling in both advective and estuarine systems is basically an attempt to keep an account of the major sources and sinks of oxygen in a system composed of a number of complex interacting subsystems (segments), each with its own set of physical characteristics. The primary

sources of oxygen are: 1) dissolved oxygen in tributary inflow waters, and 2) atmospheric reaeration. In some cases, the action of algae will, through photosynthesis, add oxygen to water. The primary sinks for oxygen are: 1) carbonaceous demands, 2) nitrogenous demands, 3) benthic demands, and 4) biological respiration.

Hydrodynamic factors fix the transport of oxygen and oxygen-demanding materials in and out of each segment. In a river or stream this is accomplished by advection. In an estuary these factors consist of dispersive and advective components, freshwater flow and circulation. These parameters are significantly affected by the geometry and shape of each segment in the system.

B) Segmentation

One of the first steps in most modeling effort is the segmentation. In AUTOSS, the computational elements are similar to those used in the QUAL-II model. Unlike QUAL-II, in AUTOSS, the length of the computational element can be changed simply by changing the number of elements employed by the model. There is no flag field to change since all parameters and loads are designated by river mile. As pointed out in the model advantages, descriptive data such as depth, temperature, decay rates are read in at different locations on the stream and intermediate values are interpolated within the program.

C) Hydraulics

1) Geometry

Computationally AUTOSS assumes a uniform, rectangular channel in between junction midpoints. The starting and ending miles are the midpoints of the first and last junctions, respectively. The physical properties width and depth are read in as input to the model. Depth is given by the equation $D = A_1 Q^{A_2} + A_3$, where A_1, A_2, and A_3 are empirical constants. The coefficients are entered as point input and interpolated over the segment. The physical geometry taken during a 1972 study by Civil Engineering Systems, Inc. was considered adequate to represent the January, 1976 conditions in the San Jacinto River. The depth was essentially invariant during the surveys with the exception of tidal effects.

2) Velocity

The net velocity in an estuary is generally a function of the freshwater moving toward the sea, the back and forth movement of the tide, the density currents and other things such as ship traffic. In AUTOSS the average tidal velocity (regardless of direction) must be entered into the model. This velocity is used only to compute reaeration rates. If no tidal velocities are specified, or they are zero, the net velocity is computed in the flow computations. The velocities used for the San Jacinto River were computed using the method outlined in a TWQB technical report entitled "Tidalc-A Program for Calculating Tidal Velocities."

3) Dispersion

For the San Jacinto River, in addition to freshwater inflow, the tidal action from the ocean is a significant hydrodynamic parameter. The dispersive mass transport due to tidal mixing by tidal flow reversals is the primary difference between estuaries and one-dimensional river flow situations. Therefore, this important transport phenomena in addition to the net freshwater flow through the estuary must be included in any modeling analysis. The coefficient of dispersion must be precalculated from the upstream gradient of salinity as the measure of the dispersion or from dye studies.

A dye study conducted on the San Jacinto River found dispersion rates of 40-50 ft^2/sec. The dye was injected at the surface and monitored for one to two days. The rates found in this study indicate only the surface dispersion rates. A longer dye study would be necessary to make a determination of the real tidal dispersion rates. Dispersion rates determined from salinity profiles are indicative of the tidal dispersion. Analysis of the average salinity profile indicated dispersion rates of 2200-5600 ft^2/sec. The higher dispersion rates were felt to be more representative and were used in the model.

D) Atmospheric Reaeration

The reaeration process is generally a function of temperature, stream geometry and stream hydraulics. Many techniques and equations have been developed to estimate reaeration coefficients based on stream geometry and stream characteristics. AUTOSS uses the O'Connor-Dobbins formula

$$K_2^{20} = \frac{12.9\,\bar{U}^{.5}}{D^{1.5}}$$

where:

D = mean stream depth, feet

$\bar{U}$ = mean velocity, feet/day

K_2 = reaeration coefficient, 1/day

E) Carbonaceous Demands

Wastewater discharges from various types of treatment plants generally contain organic materials which will decompose in the presence of oxygen and certain bacteria. The bacteria which degrade the carbonaceous component of these organic materials are present in most waters and they begin the process of decomposition quickly. Carbonaceous oxygen demand is usually determined in the five-day biochemical oxygen demand test (BOD_5). In this test, the amount of oxygen consumed under aerobic conditions, at 20°C, is measured. It is frequently assumed that the ultimate carbonaceous demand is equal to 1.5 times the five-day oxygen demand. The existing carbonaceous BOD loadings were discussed earlier in this report. The carbonaceous decay rate used in this study was estimated to be 0.15 day^{-1} at 20°C based on the data fit in the model calibration.

F) Nitrogenous Demands

Various nitrogen compounds exert an oxygen demand as they change from one form to another. These changes in form require the presence of a specific bacterial population. This population is not always available in sufficient numbers to cause these changes, and under these circumstances, a delay or lag time is sometimes observed in the

exertion of nitrogenous oxygen demand. Nitrification in AUTOSS is assumed to occur independently of dissolved oxygen concentrations. An estimate of this demand can be made by adding the ammonia nitrogen concentration to the organic nitrogen concentration and multiplying the sum by 4.57, a factor derived from stoichiometric relationships. The nitrogenous decay rate used in this study was estimated to be 0.05 $days^{-1}$ at $20^{o}C$ based on the data fit in the model calibration. This rate was probably low during the survey due to the low temperature and relatively high flow rate.

G) Benthal Demands

Bottom deposits, generally in the form of sludges discharged from municipal or industrial wastewater treatment plants, can exert an oxygen demand. These sludges accumulate below wastewater outfalls when stream velocities or tidal mixing are not sufficient to keep solid particles in suspension. These sludges can exert an oxygen demand of from 0 to 10.0 gm O_2/M^2/day. At higher treatment levels, this benthal demand will be reduced due to the reduction in discharged solids.

H) Photosynthesis/Respiration

The presence of algae can also have an effect on dissolved oxygen in surface waters. During periods of daylight, oxygen is produced as a by-product of photosynthesis. Oxygen is consumed during respiration. This complex system, involving both a source and a sink of oxygen, frequently results in a diurnal variation in dissolved oxygen concentrations. The photosynthesis/respiration system can result in either a surplus or deficit of oxygen depending on a number of conditions including light intensities, available nutrients, and turbidity. The AUTOSS model can account for photosynthesis and respiration separately. Each value in gms/O_2/M^2/day represents a 24-hour average is not corrected for temperature. No chlorophyll a was found during the January survey to indicate the presence of algae.

I) Coliforms

AUTOSS does not contain an option for coliform. However, since coliform die-off is a first-order reaction like CBOD decay, the coliforms can be input in place of the CBOD waste loads. In this case, the CDECAY rate would be the

coliform die-off rate and the output in the CBOD plot would be coliform. A literature value of 0.1 $days^{-1}$ was chosen as the die-off rate.

J) Temperature Correction Factors

Many of the reactions which determine water quality in natural systems are dependent on temperature. This dependence is usually considered by changing the various rate constants according to the following equation:

$$K_T = K_{20}\ \underline{\theta}^{(T-20)}$$

where K_T and K_{20} are rate constants at a temperature, T, and a 20° centigrade, and $\underline{\theta}$ is a temperature correction factor which depends on the reaction being considered. The following temperature correction factors are used:

Reaction	θ, Temperature Correction Factor
Atmospheric Reaeration	1.024
Carbonaceous Decay	1.047
Nitrogenous Decay	1.017

The model does not correct the benthal demand or photosynthesis-respiration parameters for temperature.

VI. MODEL ANALYSIS

A calibration of the AUTOSS model for the San Jacinto River was made using data gathered by the City of Houston and TWQB self-reporting data. The input data is given in Attachment H. The calibration is shown in Attachment J. Good agreement is shown between the calculated and the observed values for dissolved oxygen and biochemical oxygen demand. Minor differences between calculated and observed values may be attributed to numerous causes including but not limited to: a possible lack of steady-state conditions during the survey, unaccounted nonpoint sources of pollution, unaccounted effects such as toxicity and inhibition, the possible presence of algae, and sampling and measurement errors. Given the reasonably good

agreement shown in the calibration, the AUTOSS computer simulation model for the San Jacinto River, discussed in this report, can be used to evaluate a variety of alternative treatment schemes for the San Jacinto River.

VII. SENSITIVITY ANALYSIS

The output of any water quality simulation model depends on the hydraulics, rates, and waste loads which are input to the model. A list of the input values is given in Attachment H. It is useful to determine the sensitivity of the output to changes in input values. In the following sensitivity analysis, all but one parameter are held constant, and the remaining parameter value is varied by ± 20% about the value used in the calibrated model. The selection of a 20% variation is purely arbitrary. The following table list changes in the dissolved oxygen at a critical point in the dissolved oxygen profile. The point chosen is at river mile 7 of the San Jacinto River model and has a value of 6.03 mg/l in the calibrated model. The table shows only relative sensitivity of model output to changes in the input values.

Sensitivity of Model Output to Changes In Input Parameters. Dissolved Oxygen Concentrations at River Mile 7

	-20%*	+20%*	Difference
Dissolved Oxygen, Houston Ship Channel	5.10	6.97	1.87
Dissolved Oxygen, Lake Houston	5.54	6.54	1.00
River Depth	6.51	5.67	0.84
NDECAY, Nitrogenous BOD Decay Rate	6.36	5.72	0.64
Temperature	6.33	5.73	0.60
NBOD, Houston Ship Channel	6.32	5.74	0.58
Flow, Houston Ship Channel	5.76	6.29	0.53
River Width	6.35	5.82	0.53

	-20%*	+20%*	Difference
CDECAY, Carbonaceous BOD Decay Rate	6.16	5.91	0.25
CBOD, Houston Ship Channel	6.14	5.92	0.22
NBOD, Lake Houston	6.12	5.94	0.18
Dispersion	5.97	6.11	0.14
CBOD, Lake Houston	6.09	5.97	0.12
River Velocity	5.97	6.08	0.11
Effluent Flow	6.03	6.02	0.01
Effluent CBOD	6.03	6.03	0.00
Effluent NBOD	6.03	6.03	0.00

* For temperature, $\pm$ 2°C.

The table indicates the importance of the boundary conditions. The dissolved oxygen at the Houston Ship Channel and at Lake Houston have the biggest effect on the model. Also, it should be noted that the waste loads at their present levels have a small effect on the water quality in the San Jacinto River while the quality in the Houston Ship Channel has a much greater effect.

VIII. RECOMMENDATIONS FOR MODEL USE

It should be understood that the model calibration described in this report describes only a single set of conditions which existed in the San Jacinto River during a particular set of conditions (flow, waste loads, temperature, etc.). Very careful consideration must be given to any changes in the listed input conditions. A change in one parameter might easily necessitate some change in a related rate or coefficient. For this reason, any alternate treatment scheme which is sent to the Texas Water Quality Board for evaluation of receiving water quality impact must be adequately described. Attachment K at the end of this report should be used to describe these alternate treatment schemes.

Some general comments can be made concerning the alternative runs without knowing the specifics of each alternative treatment scheme. The following recommendations are meant only as a general statement of parameter changes.

Geometry - The depth and width measurements will be considered accurate for all alternative runs. The San Jacinto River is tidally influenced, and changes in flow have a small effect on the geometry.

Velocities - The velocities were obtained using a tidal cubature method with a headwater flow (from Lake Houston) of 500 cfs. For other headwater flow conditions, the velocities will be recalculated using the tidal cubature method.

Dispersion - The dispersion rates were calculated based on the salinity profile. They will be considered acceptable for the range of flows to be used in the alternative runs.

Temperature - The temperature will be input according to the conditions to be modeled.

Carbonaceous BOD Decay Rate - The CBOD decay rate will be considered acceptable for the alternative runs.

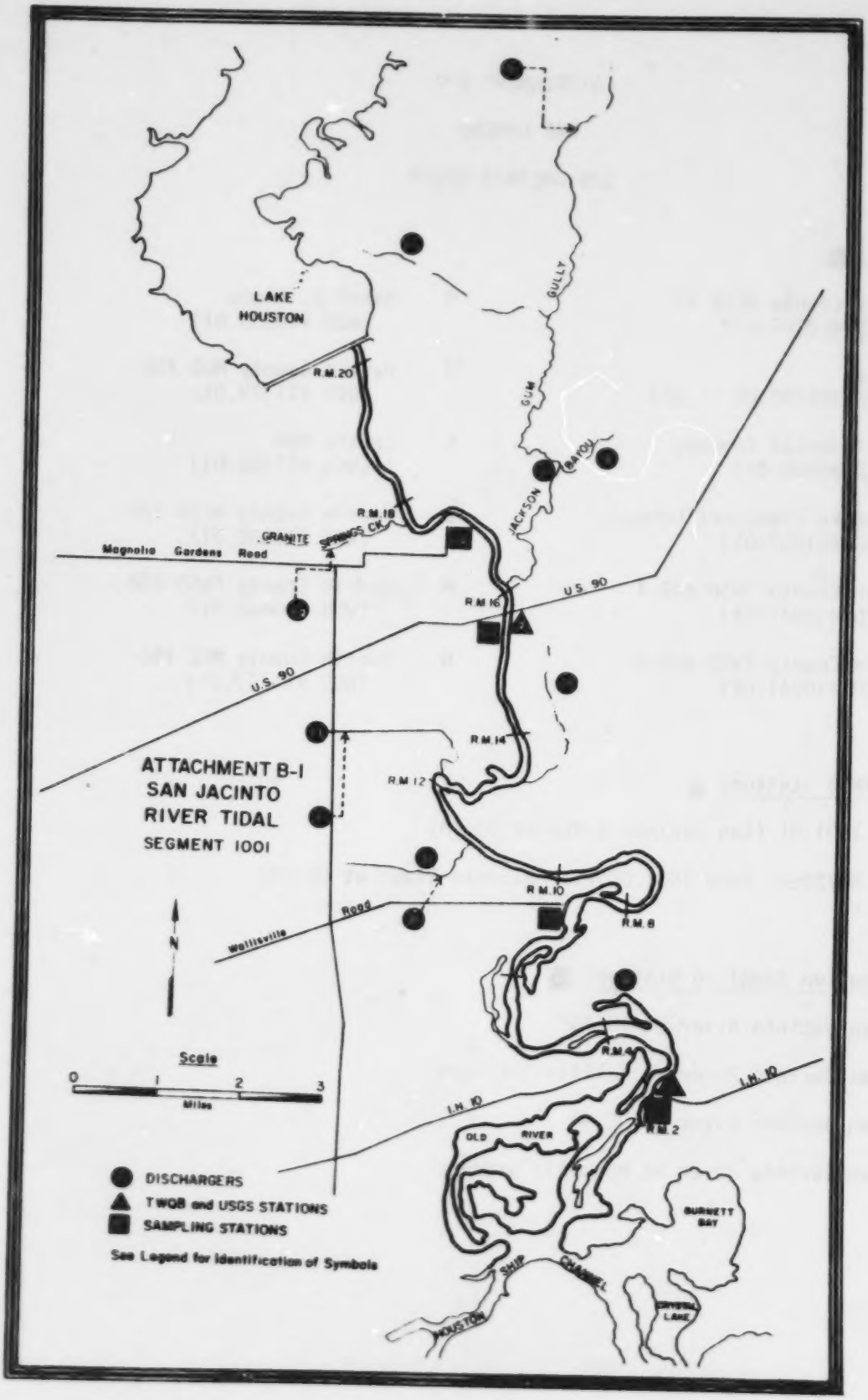
Nitrogenous BOD Decay Rate - The NBOD decay rate for the calibration run is low due to the low river temperature even though the model has a temperature correction factor. At higher temperatures (i.e., summer conditions), the NBOD decay rate is more likely to be approximately equal to 0.10.

Waste Load Flows, CBOD, NBOD, DO - The model is going to be very sensitive to the boundary conditions of CBOD, NBOD, and DO. The Houston Ship Channel is the dominating factor controlling water quality in the San Jacinto River. Careful consideration should be given in choosing the Houston Ship Channel boundary conditions. The water quality in the Houston Ship Channel must be specified for the alternative runs.

IX. SUMMARY

The staff of the Texas Water Quality Board has reviewed the data gathered in the San Jacinto River by the City of Houston. Using this data and monitoring data from the Texas Water Quality Board, a one-dimensional steady-state computer model has been calibrated for use by the Texas Water Quality Board and related planning agencies.

ATTACHMENTS


LAKE HOUSTON
R.M.20
GUM GULLY
JACKSON BAYOU
R.M.18
GRANITE SPRINGS CK.
Magnolia Gardens Road
U.S. 90
R.M.16
U.S. 90
R.M.14
R.M.12
ATTACHMENT B-I
SAN JACINTO
RIVER TIDAL
SEGMENT 1001
R.M.10
R.M.8
Wallisville Road
N
Scale
0 1 2 3
Miles
R.M.4
I.H. 10
I.H. 10
R.M.2
OLD RIVER
BURNETT BAY
HOUSTON SHIP CHANNEL
CRYSTAL LAKE
DISCHARGERS
TWQB and USGS STATIONS
SAMPLING STATIONS
See Legend for Identification of Symbols

ATTACHMENT B-2

MAP LEGEND

SAN JACINTO RIVER

Dischargers ●

A Harris County WCID #1 (WCO #10104.01)

B Baroid (WCO #01198.01 - .02)

D Arco Chemical Company (WCO #0039.01)

E Groendyke Transport Company (WCO #01057.01)

F1 Harris County FWSD #48-1 (WCO #10541.01)

F2 Harris County FWSD #48-2 (WCO #10541.02)

H Mabel G. Young (WCO #10333.01)

J Harris County MUD #20 (WCO #11329.01)

K Crosby MUD (WCO #11388.01)

L Harris County WCID #70 (WCO #10530.01)

M Harris County FWSD #58 (WCO #10668.01)

N Harris County MUD #50 (WCO #11770.01)

USGS and TWQB Stations ▲

1 TWQB 1001.01 (San Jacinto River at IH 10)

2 USGS 8072050; TWQB 1001.02 (San Jacinto River at US 90)

City of Houston Sampling Stations ■

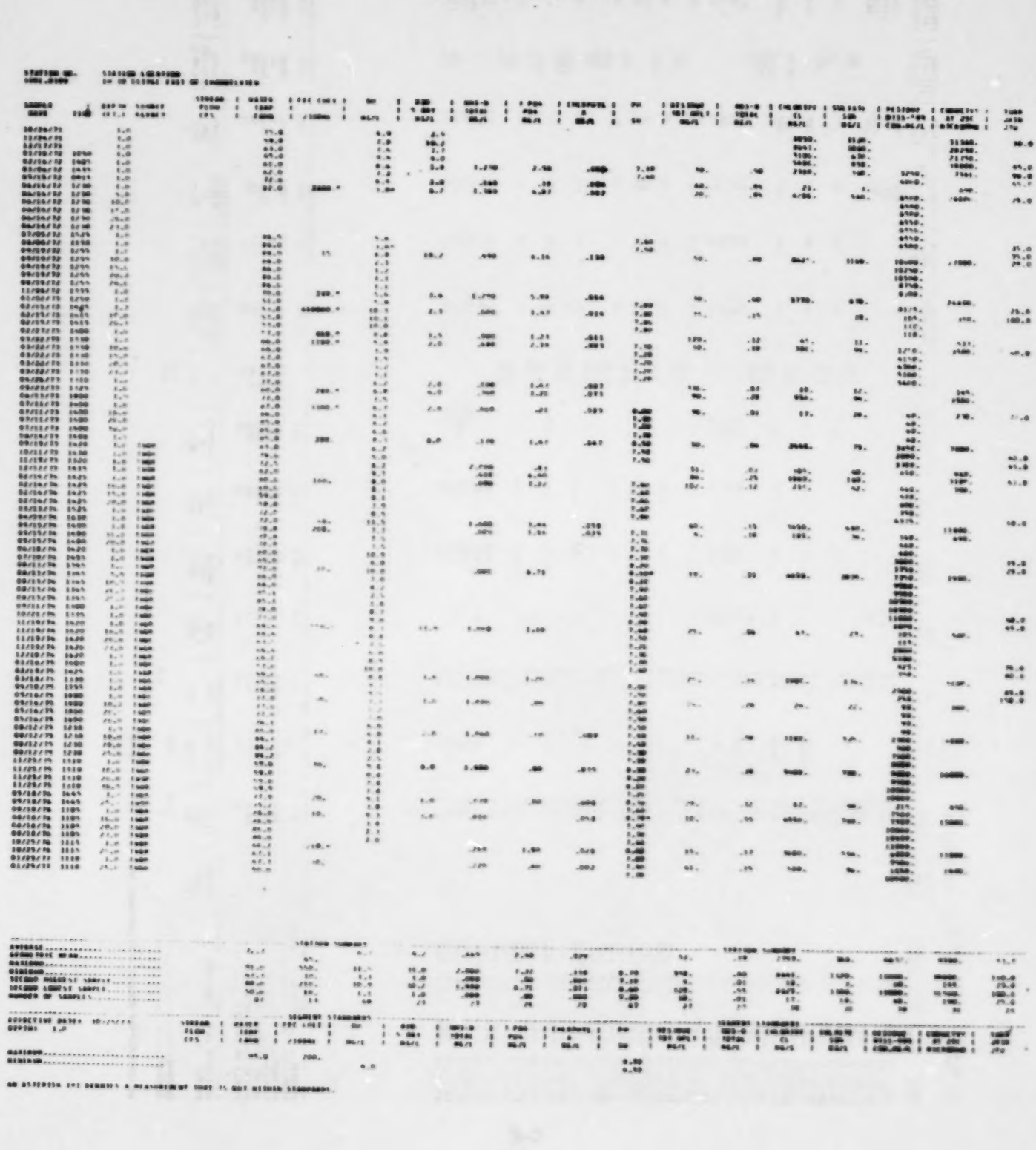
I San Jacinto River at IH 10

II San Jacinto River at Wallisville Road

III San Jacinto River at US 90

IV San Jacinto River at Magnolia Gardens

ATTACHMENT C
TWQB STREAM MONITORING DATA
SAN JACINTO RIVER



STATION NO. STATION LOCATION
1001.0200 U. S. HWY 91, MILES EAST OF THELMA

SAMPLE DATE	TIME	DEPTH (FT.)	LOCATE (LONG.)	STREAM FLOW CFS	WATER TEMP FAHR	FEC COLI /100ML	DO MG/L	BOD 5 DAY MG/L	NH3-N TOTAL MG/L	T PO4 PO4 MG/L	CHLRPHYL A MG/L	PH SU	RESIDUE TOT NFLT MG/L	NO3-N TOTAL MG/L	CHLORIDE CL MG/L	SULFATE SO4 MG/L	RESIDUE DISS-SOL CON.MG/L	CNDUCTVY AT 25C MICROMHO	TURB JKSN JTU
10/31/71		3.0			80.0		11.6	3.5							5290.	760.		20160.	35.0
11/09/71		3.0			63.0		9.2	6.9							5950.	740.		21800.	25.0
12/13/71		3.0			57.0		5.0	6.5							857.	110.		5120.	
01/18/72	1345	3.0			65.0		12.0	7.0							1550.	200.		9600.	30.0
02/04/72	1000	3.0			65.0		8.4					7.60					300.		90.0
03/13/72	1000	3.0			67.0		8.6					7.40					750.		120.0
04/20/72	1220	3.0			76.0		8.4	5.0	.430		.016		30.	.19	27.	7.		210.	
05/30/72	1000	3.0			76.0		7.6					6.90					50.		80.0
06/21/72	0910	3.0			86.0		6.8					7.10					1550.		30.0
07/12/72	1230	3.0			88.0	46000.*	12.4	2.4	.000	1.23	.040		20.	.00	660.	145.		4130.	
08/04/72	1330	3.0			86.0		6.2					7.50							15.0
09/05/72	1200	3.0			87.0		6.6					8.10					5450.		35.0
10/17/72	1030	3.0			80.0	1500.*	8.8	3.0	.000	3.37	.021		10.	.04	5920.	600.		16900.	30.0
11/07/72	1100	3.0			85.0		6.6					7.80					2000.		30.0
12/04/72	0900	3.0			75.0		6.8					8.00					4750.		35.0
01/23/73	1100	3.0			67.0		6.6					7.40					750.		50.0
02/20/73	0915	3.0			55.0	930.*	7.4	1.5	.050	.76	.016		19.	.08	2[illegible].	8.		425.	
03/26/73	1150	3.0			63.0		8.4	2.0	.000	.65	.001		60.	.14	16.	11.		500.	
04/25/73	1110	3.0			73.0	75.	6.8	4.0	.000	.76	.004		65.	.18	[illegible]	10.		117.	
05/21/73	0955	3.0			77.0		6.6	5.0	.000	.50	.016		45.	.21	1[illegible].	5.		150.	
06/28/73	1435	3.0			89.0		7.8												100.0
07/19/73	0800	3.0			84.0	3.	5.2	2.0	.320	.45	.012		0.	.03	10.	59.		200.	95.0
08/22/73	1365	3.0			87.0		6.2					7.70					110.		40.0
09/13/73	0940	3.0	TWDP		82.0		5.8					7.50					300.		50.0
10/10/73	0930	3.0	TWDP		70.0	10.	5.8	1.0	.000	2.00			23.	.06	15.	7.		100.	45.0
11/07/73	0910	3.0	TWDP		71.0		8.2					7.10					7000.		70.0
12/11/73	1000	3.0	TWDP		59.0		10.6		.200	3.32			17.	.19	20.	15.		140.	45.0
01/03/74	1010	3.0	TWDP		49.0	200.	11.1		1.200	3.16			23.	.07	22.	17.		110.	50.0
02/13/74	0920	3.0	TWDP		56.0		10.2					6.90					400.		60.0
03/26/74	0930	3.0	TWDP		67.0	12.	9.2		.000	.53			16.	.13	31.	23.		160.	50.0
04/01/74	1045	3.0	TWDP		68.0		9.5					7.70					200.		35.0
05/08/74	0910	3.0	TWDP		79.0		8.1					7.40					200.		40.0
06/13/74	0930	3.0	TWDP		83.0		7.3					7.50					950.		40.0
07/02/74	1050	3.0	TWDP		85.0		7.4		.000	1.04			22.	.01	240.	40.		900.	
08/14/74	1025	3.0	TWDP		87.0		10.9					7.10					3750.		40.0
09/10/74	0850	3.0	TWDP		76.0		6.9					7.20					5000.		50.0
10/16/74	0920	3.0	TWDP		69.0	10.	9.0		3.600	1.93	.048		16.	.06	220.	16.		170.	
11/04/74	0840	3.0	TWDP		74.0		8.2					7.40					1000.		95.0
12/12/74	0930	3.0	TWDP		62.0		9.3					7.70					900.		80.0
01/14/75	1110	3.0	TWDP		53.0	40.	11.9		1.000	.93			14.	.12	15.	26.		130.	
02/25/75	0950	3.0	TWDP		62.0		10.1					7.60					125.		90.0
03/03/75	1040	3.0	TWDP		60.0		9.3					7.00					150.		80.0
04/23/75	0945	3.0	TWDP		60.0		9.7		1.000	.80			20.	.21	24.	25.		170.	
07/10/75	1155	3.0	TWDP		86.0	70.	7.5	2.0	1.000	.00			19.	.14	19.	16.	171.	195.	90.0
10/01/75	1010	3.0	TWDP		76.0	10.	7.9		1.000	.80			8.	.04	735.	105.		2450.	
01/05/76	1105	3.0	TWDP		48.0	30.	12.0	1.0	.070	.00	.015		10.	.13	33.	17.		200.	
04/05/76	1000	3.0	TWDP		68.0	60.	9.4		.020	.00			14.	.19	411.	76.	898.	1600.	50.0
07/12/76	1200	3.0	TWDP		83.0	10.	8.2		.020	.00			17.	.01	19.	1.	136.	150.	

STATION SUMMARY

AVERAGE	72.4		8.4	3.4	.472	1.01	.018		22.	.11	864.	122.	1537.	3438.	56.5
GEOMETRIC MEAN		23.													
MAXIMUM	89.0	200.	12.4	7.0	3.600	3.37	.048	8.10	65.	.21	5956.	760.	7000.	21800.	120.0
MINIMUM	48.0	10.	5.0	1.0	.000	.00	.001	6.90	0.	.00	6.	1.	50.	100.	15.0
SECOND HIGHEST SAMPLE	88.0	60.	12.0	6.9	1.200	3.32	.040	8.00	60.	.21	5325.	740.	5650.	20160.	100.0
SECOND LOWEST SAMPLE	49.0	10.	5.2	1.0	.000	.00	.004	6.90	8.	.01	10.	5.	110.	110.	25.0
NUMBER OF SAMPLES	48	18	48	15	21	20	18	22	21	21	2[illegible]	25	24	25	34

EFFECTIVE DATE: 10/25/75
DEPTH: 1.0

SEGMENT STANDARDS

STREAM FLOW CFS	WATER TEMP FAHR	FEC COLI /100ML	DO MG/L	BOD 5 DAY MG/L	NH3-N TOTAL MG/L	T PO4 PO4 MG/L	CHLRPHYL A MG/L	PH SU	RESIDUE TOT NFLT MG/L	NO3-N TOTAL MG/L	CHLORIDE CL MG/L	SULFATE SO4 MG/L	RESIDUE DISS-SOL CON.MG/L	CNDUCTVY AT 25C MICROMHO	TURB JKSN JTU
MAXIMUM	99.0	200.						8.50							
MINIMUM			4.0					6.50							

AN ASTERISK (*) DENOTES A MEASUREMENT THAT IS NOT WITHIN STANDARDS.

ATTACHMENT D-1

SAN JACINTO RIVER DIURNAL FIELD MEASUREMENTS
JANUARY 13, 1976 CITY OF HOUSTON SURVEY

Station Location	Dissolved Oxygen (mg/l)		Temperature (°F)		Average pH	Average Conductivity (μmhos/cm)
	Range	Average	Range	Average		
IH 10	4.4-8.8	6.4	55-59	57	6.5	9,418
Wallisville Road	4.4-8.2	6.0	54-63	58	6.4	7,050
US 90	4.4-9.0	7.0	54-60	55	6.5	3,145
Magnolia Gardens	5.8-9.4	7.9	56-60	58	6.5	254

ATTACHMENT D-2

SAN JACINTO RIVER LABORATORY ANALYSES
JANUARY 13, 1976 CITY OF HOUSTON SURVEY

Station Location	BOD_5 (mg/l)	Org-N (mg/l)	NH_3 (mg/l)	NO_2 (mg/l)	NO_3 (mg/l)	Total P (mg/l)	Chloro a (mg/l)	TSS (mg/l)	TDS (mg/l)
IH 10	2.0	1.65	2.2	0.045	0.36	0.65	0	9.0	10,298
Wallisville Road	1.5	3.03	2.2	0.040	0.52	0.50	0	4.0	7,252
US 90	1.0	0.84	1.7	0.020	0.48	0.25	0	16.5	2,204
Magnolia Gardens	1.0	0.65	0.6	0.015	0.35	0.30	0	14.5	178

ATTACHMENT D-3

SAN JACINTO RIVER DIURNAL COLIFORM ANALYSES
JANUARY 13, 1976 CITY OF HOUSTON SURVEY

Station Location	Total Coliform (MPN/100 ml) Range	Total Coliform (MPN/100 ml) Log Average	Fecal Coliform (MPN/100 ml) Range	Fecal Coliform (MPN/100 ml) Log Average
IH 10	110- 390	238	20- 80	34
Wallisville Road	2200-22,000	7,539	130-500	226
US 90	70- 1,300	389	20- 80	36
Magnolia Gardens	220- 700	376	20- 50	26

ATTACHMENT E

EXISTING WASTE LOADS ON SAN JACINTO RIVER

		WCO No.	River[a] Mile		Flow[b] (MGD)	BOD_5[b] (mg/l)	NH_3[c] (mg/l)	BOD_5 (#/day)	L_o (#/day)	N_o (#/day)	Total (#/day)
A	Harris Co. WCID #1	10104.01	3.6	Existing	0.782	18.5	3.0	121	181	89	270
				Permitted	0.750	20.0	---	125	188	--	---
B	Baroid	01198.01 01198.02	11.1	Existing	0.004	6.7	8.0	<1	<1	1	1
				Permitted	0.010	----	---	3.5	5	--	---
D	Arco Chemical Co.	00391.01	11.1	Existing	2.251	2.7	0.4	51	76	34	110
				Permitted	4.400	----	---	318	---	--	---
E	Groendyke Transport Co.	01057.01	12.1	Existing	No Discharge Permit.			---	---	--	---
				Permitted	No Discharge Permit.			---	---	--	---
F1	Harris Co. FWSD #48-1	10541.01	12.1	Existing	0.300	26.1	8.4	65	98	96	194
				Permitted	0.210	20.0	---	35	53	--	---
F2	Harris Co. FWSD #48-2	10541.02	17.7	Existing	0.015	11.4	8.0	1	2	5	7
				Permitted	0.220	20.0	---	37	55	--	---
H	Vornsand Enterprises (Mabel G. Young)	10333.01	13.7	Existing	0.047	18.0	8.0	7	11	14	25
				Permitted	0.098	20.0	---	16	25	--	---
J	Harris Co. MUD #20	11329.01	16.0	Existing	0.148	2.9	8.0	4	5	45	50
				Permitted	0.450	20.0	---	75	113	--	---

		WCO No.	River[a] Mile		Flow[b] (MGD)	BOD_5[b] (mg/l)	NH_3[c] (mg/l)	BOD_5 (#/day)	L_p (#/day)	N_p (#/day)	Total (#/day)
K	Crosby MUD	11388.01	16.0								
				Existing	0.102	3.4	8.0	3	4	31	35
				Permitted	0.250	20.0	---	42	63	--	---
L	Harris Co. WCID #70	10530.01	16.0								
				Existing	0.098	4.0	8.0	3	5	30	35
				Permitted	0.350	20.0	---	58	88	--	---
M	Harris Co. FWSD #58	10668.01	16.0								
				Existing	0.039	12.8	8.0	4	6	12	18
				Permitted	0.100	20.0	---	17	25	--	---
N	Harris Co. MUD #50	11770.01	13.7								
				Existing	Not yet constructed.			---	---	--	---
				Permitted	0.550	20.0	---	92	138	--	---

[a] If discharger is located on tributary, river mile indicates where tributary enters the San Jacinto River.

[b] Based on average TWQB self-reporting data from January 1976 through September 1976.

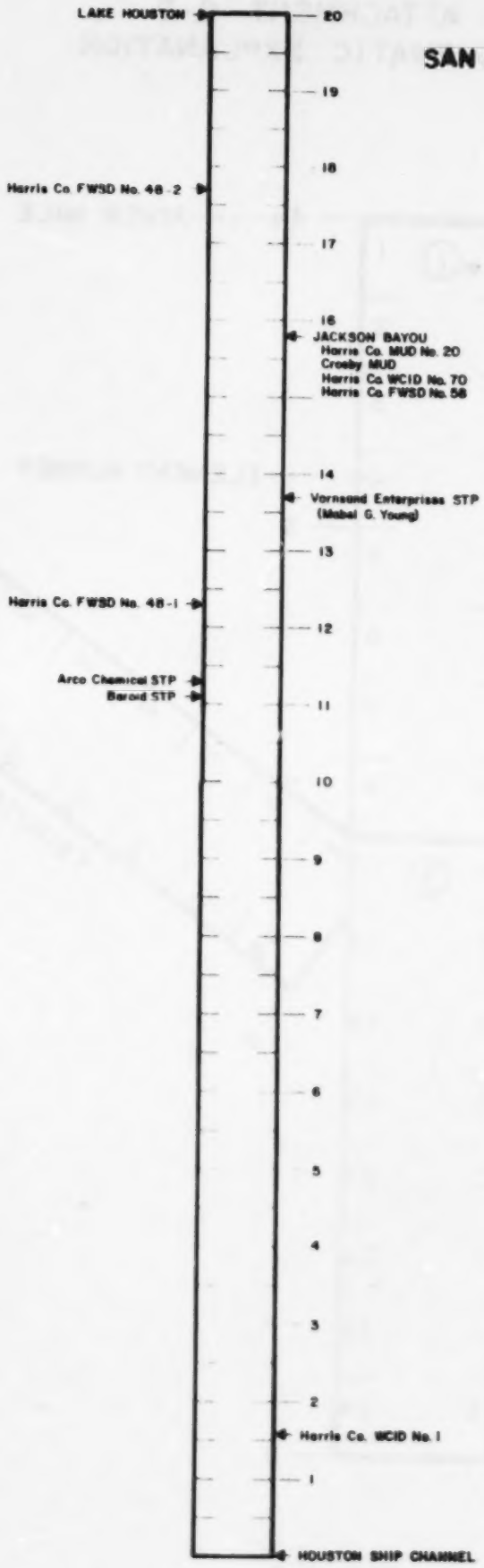
[c] Based on return flow data and field measurements.

ATTACHMENT F

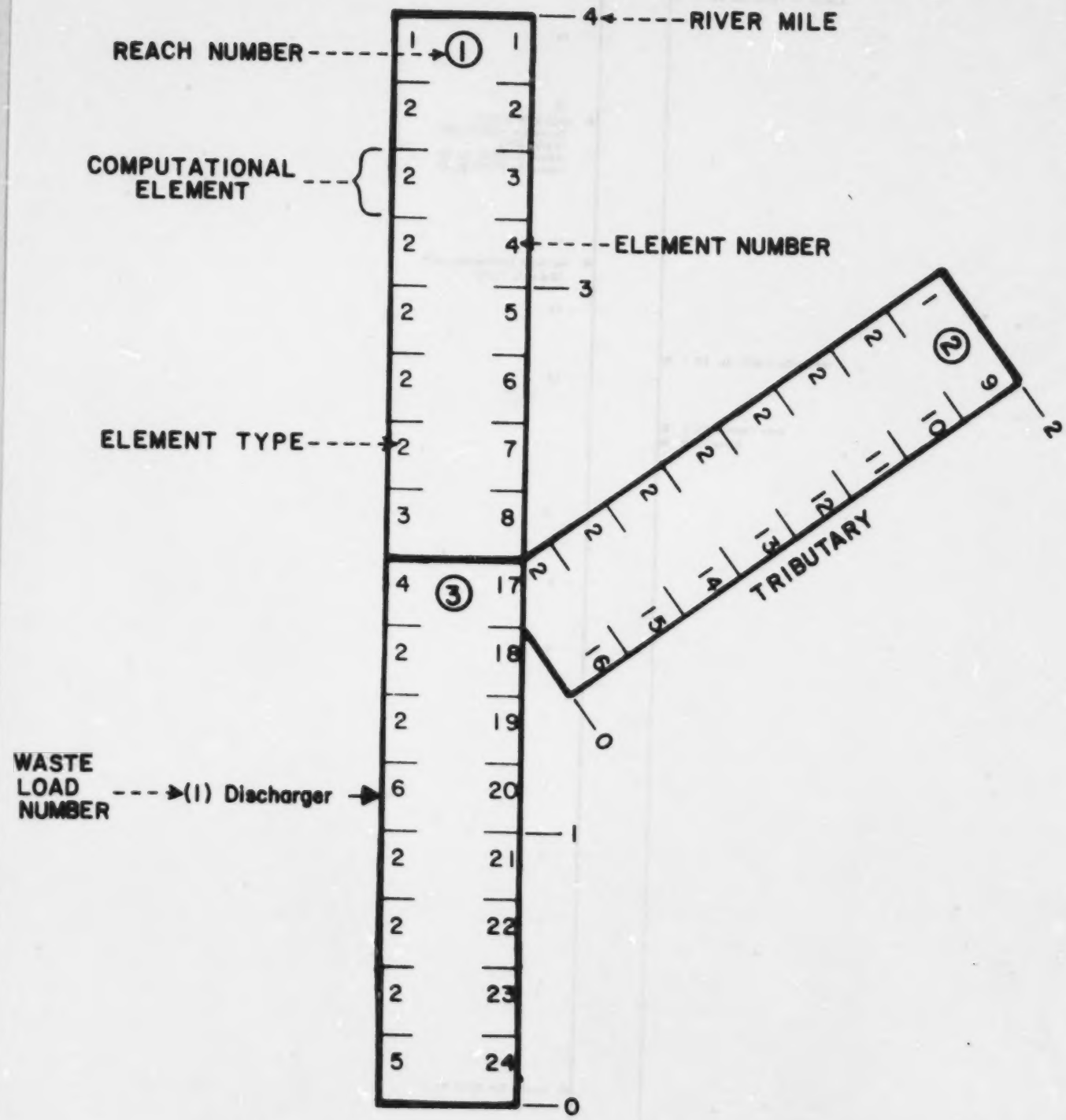
SAN JACINTO RIVER WASTE LOADS
January 13, 1976

	Flow (cfs)	BOD_5 (mg/l)	BOD_u (mg/l)	Org-N (mg/l)	NH_3 (mg/l)	NO_2 (mg/l)	NO_3 (mg/l)	NBOD (mg/l)	TSS (mg/l)	Total P (mg/l)	Total Coliform (MPN/100 ml)	Fecal Coliform (MPN/100 ml)
Harris Co. WCID #1	1.510	20	30	5.00	3.0	0.15	4.85	36.6	22	5.2	151	34
Baroid	0.002	8	12	9.00	8.0	----	-----	77.7	--	---	---	--
Arco Chemical	2.670	4	6	1.05	0.4	0.10	7.95	6.6	13	0.8	412	<43
Harris Co. FWSD #48-1	0.460	18	27	2.10	8.4	0.02	16.70	48.0	44	9.5	333	<20
Harris Co. FWSD #48-2	0.240	16	24	9.00	8.0	----	-----	77.7	--	---	---	--
Mabel G. Young	0.070	18	27	9.00	8.0	----	-----	77.7	--	---	---	--
Harris Co. MUD #20	0.220	13	19.5	9.00	8.0	----	-----	77.7	--	---	---	--
Crosby MUD	0											
Harris Co. WCID #70	0.110	4	6	9.00	8.0	----	-----	77.7	--	---	---	--
Harris Co. FWSD #58	0.150	16	24	9.00	8.0	----	-----	77.7	--	---	---	--
Harris Co. MUD #50	0											

ATTACHMENT G - 1
SAN JACINTO RIVER SCHEMATIC



ATTACHMENT G-2
SCHEMATIC EXPLANATION

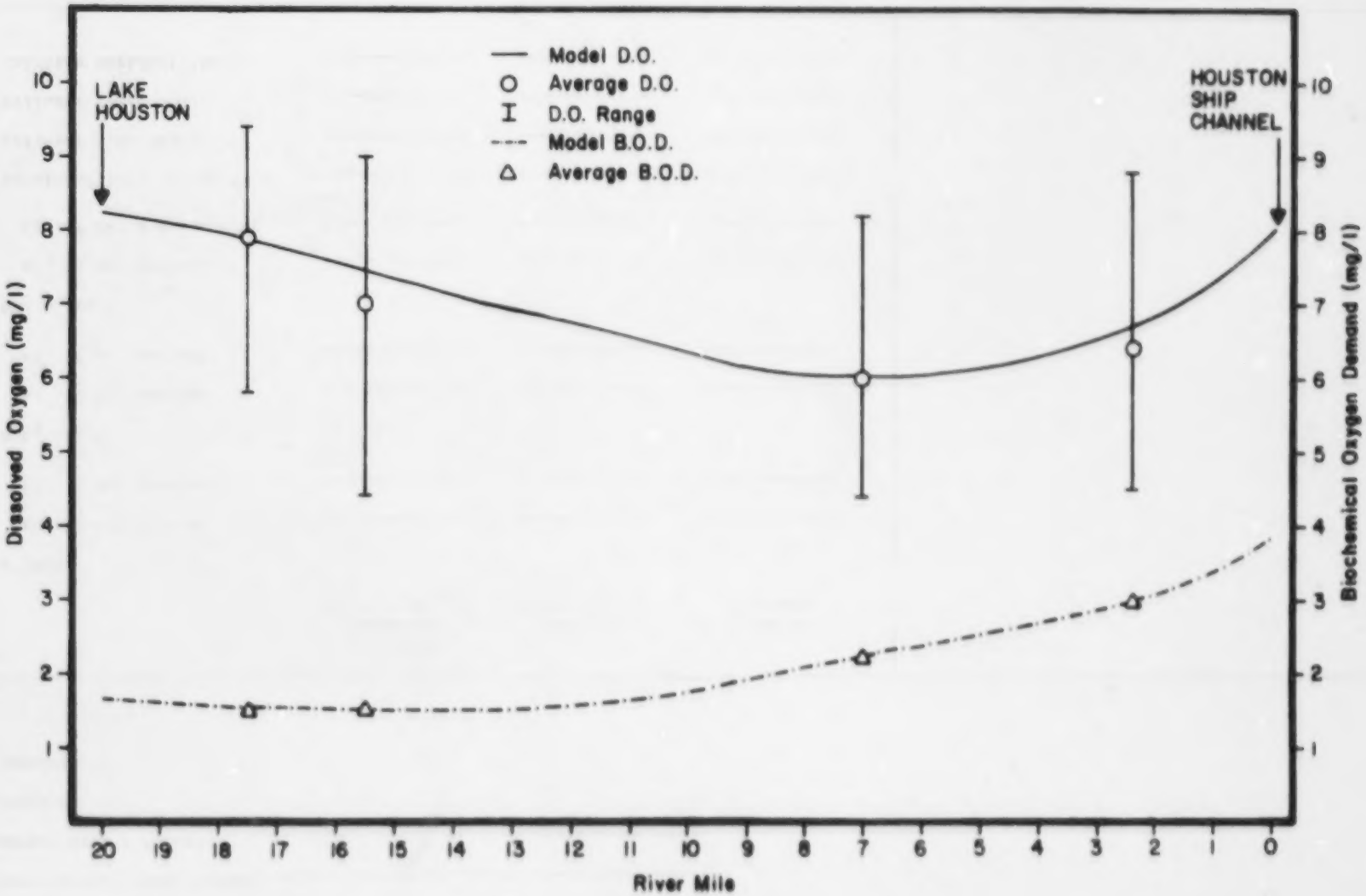


ATTACHMENT H

SAN JACINTO RIVER
AUTO-QUAL MODEL INPUT

```
SAN JACINTO RIVER-SEGMENT 1001                          RUN #25
     0.0        20.        20.          40
DATA
WIDTH          20
    1           0.5       542.
    2           1.5       602.
    3           2.5       540.
    4           3.5       531.
    5           4.5       450.
    6           5.5       366.
    7           6.5       313.
    8           7.5       315.
    9           8.5       317.
   10           9.5       332.
   11          10.5       332.
   12          11.5       332.
   13          12.5       332.
   14          13.5       332.
   15          14.5       332.
   16          15.5       260.
   17          16.5       260.
   18          17.5       260.
   19          18.5       390.
   20          19.5       390.
DISP           20
    1           0.5      3700.
    2           1.5      4100.
    3           2.5      5600.
    4           3.5      4000.
    5           4.5      3800.
    6           5.5      4600.
    7           6.5      4600.
    8           7.5      3900.
    9           8.5      2800.
   10           9.5      2200.
   11          10.5      2200.
   12          11.5      2800.
   13          12.5      2800.
   14          13.5      3800.
   15          14.5      2900.
   16          15.5      3700.
   17          16.5      4300.
   18          17.5      4600.
   19          18.5      4600.
   20          19.5      4600.
VELO           20
    1           0.5         .111
    2           1.5         .062
    3           2.5         .083
    4           3.5         .062
    5           4.5         .056
    6           5.5         .064
    7           6.5         .080
    8           7.5         .062
    9           8.5         .065
   10           9.5         .089
   11          10.5         .085
   12          11.5         .083
   13          12.5         .062
   14          13.5         .062
   15          14.5         .082
   16          15.5         .112
   17          16.5         .112
   18          17.5         .112
   19          18.5         .065
   20          19.5         .065
TEMP           1
    1           0.0        19.0
CDECAY         1
    1           0.0         .15
NDECAY         1
    1           0.0         .05
```

```
A3          20
    1        0.5      15.5
    2        1.5      17.5
    3        2.5      18.
    4        3.5      23.
    5        4.5      20.
    6        5.5      20.
    7        6.5      25.
    8        7.5      23.
    9        8.5      21.0
   10        9.5      18.5
   11       10.5      18.5
   12       11.5      18.5
   13       12.5      18.5
   14       13.5      18.5
   15       14.5      18.5
   16       15.5      16.
   17       16.5      16.
   18       17.5      16.
   19       18.5      15.
   20       19.5      15.0
C-SATDO
C-REAER
INITCBOD    1
    1        0.0       3.0
INITDO      1
    1        0.0       7.0
STOP
FLOW
            20.0     500.              LAKE HOUSTON
            17.7       .46             HARRIS FSWD 48-2
            15.8       .48             WCID 70,FSWD 58,MUD 20,CROSBY MUD
            13.7       .07             MABEL G YOUNG
            12.3       .46             HARRIS FSWD 48-1
            11.3      2.67             ARCO CHEMICAL
            11.1      0.002            BAROID
             3.6      1.51             HARRIS WCID 1
STOP
CBOD
            20.0     500.       2.1            LAKE HOUSTON
            17.7       .46     24.             HARRIS FSWD 48-2
            15.8       .48      8.9            WCID 70 FSWD 58,MUD 20,CROSBY
            13.7       .07     27.             MABEL G YOUNG
            12.3       .46     27.             HARRIS FSWD 48-1
            11.3      2.67      6.             ARCO CHEMICAL
            11.1      0.002    12.             BAROID
             3.6      1.51     10.             HARRIS WCID 1
FIXED        0.                          3.85 HOUSTON SHIP CHANNEL
STOP
NBOD
            20.      500.       5.8            LAKE HOUSTON
            17.7       .46     77.7            HARRIS FSWD 48-2
            15.8       .48     38.8            WCID 70,FSWD 58,MUD 20,CROSBY
            13.7       .07     77.7            MABEL G YOUNG
            12.3       .46     48.0            HARRIS FSWD 48-1
            11.3      2.67      6.60           ARCO CHEMICAL
            11.1      0.002    77.7            BAROID
             3.6      1.51     36.6            HARRIS WCID 1
FIXED        0.0                         20.  HOUSTON SHIP CHANNEL
STOP
DO
            20.0     500.      10.             LAKE HOUSTON
            17.7       .46      4.             HARRIS FSWD 48-2
            15.8       .48      8.             WCID 70 FSWD 58,MUD 20,CROSBY
            13.7       .07      4.             MABEL G YOUNG
            12.3       .46      4.4            HARRIS FSWD 48-1
            11.3      2.67      5.4            ARCO CHEMICAL
            11.1      0.002     4.0            BAROID
             3.6      1.51      4.0            HARRIS WCID 1
FIXED        0.                          8.   HOUSTON SHIP CHANNEL
STOP
HALT
```



ATTACHMENT J: CALIBRATION — JAN. 13, 1976 SURVEY RESPONSE CURVES FOR SAN JACINTO RIVER (TIDAL) MODEL

ATTACHMENT K

WASTEWATER TREATMENT PLANT DISCHARGE DESCRIPTION

Alternative Number: _____

Plant Name: _____

Waste Control Order Number: _____

Segment Name & Number: _____

Location:

Comments:

	Existing Discharge (12 Mos. Avg.)	Existing W.C.O. Limits	Proposed Discharge
Q (MGD)			
a) 30 day average	_____	_____	_____
b) 7 day average	_____	_____	_____
BOD_5 (mg/l)			
a) 30 day average	_____	_____	_____
b) 7 day average	_____	_____	_____
NH_3-N (mg/l)			
a) 30 day average	_____	_____	_____
b) 7 day average	_____	_____	_____
Fecal Coliform (#/100 ml.)	_____	_____	_____
Effluent D.O. (mg/l)	_____	_____	_____
Effluent Temp. (^{o}C)	_____	_____	_____
Chlorine Residual (mg/l)	_____	_____	_____

WATER QUALITY MODELING

FOR THE

208 DESIGNATED PLANNING AREAS

HOUSTON AREA STORMWATER MODELING REPORT

Spring Creek (Segment 1008)

Cypress Creek (Segment 1009)

Clear Creek Above Tidal (Segment 1102)

San Jacinto River Tidal (Segment 1001)
Houston Ship Channel (Segments 1005, 1006, 1007)

Prepared by:

Administrative Operations Division
Texas Department of Water Resources
Austin, Texas

for the

Houston-Galveston Area Council

and the

U.S. Environmental Protection Agency

The preparation of this report was financed through planning grants from the U.S. Environmental Protection Agency through the Houston-Galveston Area Council.

September, 1977

LIST OF ATTACHMENTS

		PAGE
1	JUNCTION-CHANNEL REPRESENTATION OF SPRING CREEK	13
2	JUNCTION-CHANNEL REPRESENTATION OF CYPRESS CREEK	15
3	JUNCTION-CHANNEL REPRESENTATION OF CLEAR CREEK	18
4	JUNCTION-CHANNEL REPRESENTATION OF THE HOUSTON SHIP CHANNEL & THE SAN JACINTO RIVER TIDAL	20
5	WRECEV INPUT DATA - Spring Creek	23
6	WRECEV INPUT DATA - Cypress Creek	25
7	WRECEV INPUT DATA - Clear Creek	27
8	WRECEV INPUT DATA - Houston Ship Channel & San Jacinto River Tidal	29
9	STORMWATER MODELING RESULTS - Spring Creek	31
10	STORMWATER MODELING RESULTS - Cypress Creek	33
11	STORMWATER MODELING RESULTS - Clear Creek	35
12	STORMWATER MODELING RESULTS - Houston Ship Channel	37
13	STORMWATER MODELING RESULTS - San Jacinto River Tidal	39
14	SENSITIVITY ANALYSIS - Dissolved Oxygen	41
15	SENSITIVITY ANALYSIS - Coliform	42
16	NONPOINT SOURCE POLLUTOGRAPHS	43
17	USGS QUANTITY/QUALITY FOR 1970-1976	44
18	CLEAR CREEK - NODE 50	45

TABLE OF CONTENTS

		PAGE
I.	INTRODUCTION	1
II.	MATHEMATICAL MODEL FORMULATION	2
III.	MODEL INPUT	4
IV.	MODEL OUTPUT	5
V.	SENSITIVITY ANALYSIS	6
VI.	CONCLUSION	6
	A) Houston Ship Channel - Sampling Priorities	7
	B) Settling of Stormwater BOD_5	8
	C) Dispersion During Unsteady Flow Conditions	8
	D) Benthal Demand	9
	E) Clear Creek - Sampling Priorities	10
	F) Fecal Coliform Simulations	10
VII.	SUMMARY	12

I. INTRODUCTION

This report has been prepared in conjunction with the stormwater modeling effort performed for the Houston-Galveston Area Council by the Texas Department of Water Resources as set forth in Task 2.63 of the 208 Work Plan. The model used is a non-steady-state model, WRECEV, prepared for the U.S. Environmental Protection Agency by Water Resources Engineers, Inc., in March, 1976.

Stormwater models have been prepared for the following stream segments located within the Houston 208 Area:

1) Spring Creek (Segment 1008)

2) Cypress Creek (Segment 1009)

3) San Jacinto River Tidal (Segment 1001)
   Houston Ship Channel (Segments 1005, 1006, 1007)

4) Clear Creek Above Tidal (Segment 1102)

The stormwater models for the above segments have been set up to predict BOD/DO and coliform concentrations in-stream during periods of unsteady flow in the streams. The inputs to the stormwater models consist of the pollutographs/hydrographs which were developed by the consultants accomplishing the non-point source waste load projection portion of the 208 Planning Program. It should be noted that the stormwater models and nonpoint source waste load projections have not been verified at the present time. This would require extensive site specific data. In their present form, the stormwater models can be used for planning purposes to screen nonpoint source waste loads to determine which of the waste loads could lead to potentially significant in-stream water quality problems. If potential stormwater problems are shown to exist from the analyses, it will be necessary to verify the existence and causes of the problems with site specific data prior to undertaking corrective programs which involve the commitment of substantial amounts of resources.

A general description of the study area along with past and present water quality conditions have been discussed in the steady-state modeling reports prepared in accordance with Task 2.63 and will not be presented here. Included in this report are a description of the model, an explanation of the data input, a brief discussion on sensitivity, and application of the model.

II. MATHEMATICAL MODEL FORMULATION

Stormwater conditions in the Houston Area were simulated using WRECEV, a modified version of the receiving water block (RECIEV) of the Storm Water Management Model (SWMM). The WRECEV model, consisting of a Hydrodynamic Module and a Water Quality Module, was chosen because of its ability to simulate the movement of water within a system during unsteady flow. The major disadvantage of WRECEV is the large amount of computer time it requires.

WRECEV uses a set of channels connected at junctions to numerically represent the system being modeled. Channel properties include length, roughness coefficient, cross-sectional area, hydraulic radius, top width, and depth. Junction properties include bottom elevation, surface area, and volume. The Hydrodynamic Module computes the flows using the finite difference forms of the continuity and energy equations. Friction losses are estimated with the Manning equation. The finite difference equations are solved numerically using the Modified Euler technique. To prevent instability and oscillations with time in the numerical solution algorithm, the following criterion for the hydrodynamic time step must be met:

$$\Delta t \leq \frac{\Delta x}{U + \sqrt{\frac{gA}{B}}}$$

where:

Δt = hydrodynamic time step

Δx = length of channel

U = velocity of flow

g = acceleration of gravity

A = cross-sectional area

B = top width

The Hydrodynamic Module is capable of handling most situations of gradually varied unsteady flow with the following limitations:

1) Wind stresses, coriolis forces, and evaporation are not included.

2) Head losses at junctions are not included.

3) Withdrawals cannot be time variant.

4) A weir or tidal stage control may occur only at the most downstream junction.

The Water Quality Module solves a one-dimensional advection-diffusion-mass transport equation using finite difference approximation to determine the temporal and spatial distribution of up to six conservative and non-conservative constituents. For accuracy and stability in the numerical solution algorithm, the following criterion for the quality time step must be met:

$$\Delta t \leq \frac{\Delta x}{U}$$

where:

Δt = quality time step

Δx = length of channel

U = velocity of flow

The following limitations exist in the Water Quality Module:

1) All constitutent reactions are limited to first order decay.

2) Only the dissolved oxygen and biochemical oxygen demand reactions are coupled.

3) Any nitrogenous oxygen demand must be included with the carbonaceous oxygen demand.

4) At any given cross-section, constituents are completely mixed.

Atmospheric reaeration is determined using the Tsivoglou-Wallace equation:

$$K_2 = k \frac{\Delta h}{t_f}$$

where:

K_2 = reaeration coefficient

k = an empirical coefficient

Δh = change in water surface elevation through the reach

t_f = time of travel through the reach

The temperature correction factors for the rate equations are input by the user. The following temperature correction factors were used in the rate correction equation $K_T = K_{20}\ \theta^{(T-20)}$:

Reaction	θ, Temperature Correction Factor
Atmospheric Reaeration	1.024
Carbonaceous Decay	1.047
Coliform Die-Off	1.047

III. MODEL INPUT

The hydraulic characteristics used in preparing the stormwater models were based primarily on data obtained from the USGS and the Corps of Engineers. Because detailed storm event data was not available for calibration, the quality coefficients were assumed to be the same as those used in the steady-state models.

The natural flow conditions were based on the average flow during July, August, and September for the past five years. These flows which were measured at the USGS gaging stations on each creek were then apportioned according to drainage area. The quality parameters associated with the natural flows are given in the following table.

TABLE 1	
Temperature	27°C
Dissolved Oxygen	Saturation (8.0 mg/l)
BOD_5	1.0 mg/l
Coliform	100 MPN/100 ml

The point source waste loads from wastewater treatment plants were input using flows as specified in their existing discharge permits. The BOD_5 and ammonia concentrations were assumed to be equal to the specified values in the existing waste load allocations. If no allocation for ammonia was given, the concentration was assumed to be 8.0 mg/l. Dissolved oxygen concentration was assumed to be 4.0 mg/l, and coliform concentration was assumed to be 200 MPN/100 ml.

The stormwater hydrographs and pollutographs provided flow, BOD_5 concentrations, and coliform concentrations. Dissolved oxygen concentration associated with the pollutograph was assumed to be 80% of the saturated value at the stream temperature.

Attachments 1-4 give a schematic representation of each model along with the location of stormwater hydrograph/pollutograph inputs and constant inputs. Attachments 5-8 show various input parameters used in each model.

IV. MODEL OUTPUT

Each stormwater simulation consists of two runs. The hydrodynamic run gives the depth in each junction and the velocity and flow in each channel at two-hour intervals. The water quality run gives the BOD, DO, and coliform concentrations in each junction at two-hour intervals.

The models were allowed to attain steady state prior to imposing the stormwater inputs upon them. For Spring Creek, Cypress Creek, and Clear Creek models, the stormwater hydrographs/pollutographs were imposed at the end of five days. The execution of these models was terminated at the end of 20 days. For the Houston Ship Channel/San Jacinto River model, the stormwater hydrographs/

pollutographs were imposed at the end of 7 days. The execution of this model was terminated at the end of 21 days.

Each model was run using the 1975 1-month storm, 1975 6-month storm, 1975 2-year storm, 1983 2-year storm, 1990 2-year storm, and 1995 2-year storm. The critical dissolved oxygen and coliform concentrations along with their location in time and space are shown in Attachments 9-13 for each model and storm.

V. SENSITIVITY ANALYSIS

The output of any water quality simulation model depends upon the input values. It is useful to determine the sensitivity of the model output to changes in these input values. In the sensitivity analysis, the BOD decay rate, the reaeration rate, and the coliform die-off rate are each varied separately by ±20 percent with all other parameters remaining constant. The selection of a 20 percent variation is arbitrary. The BOD and coliform concentration in the stormwater pollutographs are varied by +100 percent and -50 percent due to the uncertainty of these projections. The sensitivity analysis was conducted on the 2-year storm for 1975 conditions. Attachments 14 and 15 show the changes in dissolved oxygen and coliform concentration at a critical point in time and space for each model.

VI. CONCLUSION

The stormwater modeling results for the Houston Area stream segments indicate potentially significant stormwater impacts on water quality in the Houston Ship Channel (Segments 1005, 1006, 1007) and Clear Creek (Segment 1102). The other stream segments which were modeled (Segments 1008, 1009, 1001) did not exhibit significant stormwater impacts. It should be emphasized that the above analyses were accomplished with stream models which have been set up for the physical characteristics of the streams being modeled, but have not been calibrated with chemical and biological data specific to the stream and type of condition being simulated. The purpose of these analyses is to screen potential problems in order to establish priorities so that sampling programs can be designed and implemented in an economic and efficient manner.

The following sections of this report contain specific recommendations for sampling programs and recommendations for

refinement of the unsteady flow water quality models based on our experiences in performing the modeling for the Houston Area.

A) Houston Ship Channel - Sampling Priorities

The sensitivity analysis results, Attachment 14, show that the existence of a stormwater related dissolved oxygen problem in the Houston Ship Channel depends on the stormwater BOD_5 load to the Channel. If the load, as represented in the stormwater pollutographs, is reduced by 50%, the dissolved oxygen level would be 3.2 mg/l as opposed to a level of approximately 0 mg/l which results if the pollutograph for the one-hour duration - 2-year 1975 condition storm is input at its existing predicted value. The steady-state water quality standard for this section of the Channel is 2.0 mg/l at junction 9 where the minimum dissolved oxygen is predicted to occur and 4.0 mg/l further downstream in the Segment 1005 section of the Channel.

Attachment 16 contains descriptive statistics for the simulated pollutographs for Buffalo, Whiteoak, and Brays Bayous which were used as inputs to the Ship Channel unsteady flow model. As an example, for Buffalo Bayou, the simulated pollutograph for the one-hour duration two-year storm had a total volume of 2,178 million gallons, a total load of 510,462 lbs of BOD_5, a flow weighted average BOD_5 of 28.1 mg/l, a maximum BOD_5 of 211 mg/l, and a minimum BOD_5 of 1.3 mg/l.

Attachment 17 contains descriptive statistics computed from USGS water quality samples taken from Buffalo, Whiteoak, and Brays Bayous during the 1970-1976 time period. It should be pointed out that these samples were taken under both low flow and runoff conditions and they also contain significant amounts of effluent from upstream wastewater treatment plants. An attempt was made to try to differentiate the runoff samples from low flow water quality samples by grouping the samples according to flow and then computing averages. As an example, for Buffalo Bayou, the average BOD_5 of all samples was 7.6 mg/l, the flow weighted average for samples where $Q < Qav.$ was 8.8 mg/l, and the flow weighted average for samples where $Q > Qav.$ was 4.71 mg/l. As can be seen there are significant differences between the BOD_5 as measured in the bayous and those being simulated. This can be seen by comparing Attachments 16 and 17 pollutograph simulations.

In order to verify the magnitude of stormwater loads to the

Channel and the existence of stormwater problems in the Channel after a storm event, the initial sampling program should concentrate on sampling major stormwater and point source waste load inputs to the Channel during and after a storm event, and on measuring the water quality response in the Channel during and several days after the storm event. If this type of sampling program verifies the existence of a problem and source of the problem by major category (i.e., stormwater loads, point source loads, etc.), then it would be necessary to accomplish further sampling to refine the relationships and identify the cause of the problem.

B) Settling of Stormwater BOD_5

Studies of stormwater characteristics have shown that a substantial portion of the BOD_5 in stormwater is settleable within a short time.[1] In the modeling analysis, the BOD_5 in stormwater was assumed to remain in suspension with the only removal mechanism being decay of BOD_5 and concurrent uptake of dissolved oxygen. In order to refine the unsteady flow water quality model, the effect of settling of BOD_5 from the water column and the effect of the settled BOD_5 on benthal demand should be explicitly taken into account. The existing unsteady flow model in its present form should give a "conservative" estimate when considering the BOD_5 settling question. In general, when BOD_5 rapidly settles from the water column, there is less impact on the stream than in the case where the BOD_5 remains in solution, exerting an oxygen demand on the water column. In other words, if settling is significant, the impact of stormwater loads would be expected to be less then predicted by the existing model.

C) Dispersion During Unsteady Flow Conditions

The Houston Ship Channel is subject to complex hydrodynamic phenomena. When inflows are in a steady-state condition, a regular tidal pattern is being repeated, and weather conditions are stable, dispersion in the Channel can be computed using several types of tracers (i.e., salinity, various types of dyes, etc.). Past analyses of dispersion have been in general agreement as to the value of the dispersion coefficient as used for the steady-state water quality analyses. Under

---

[1] Colston, Newton V., Jr., et al., Characterization and Treatment of Urban Land Runoff, EPA-670/2-74-096, December, 1974.

steady-state conditions, there is a positive relationship between freshwater inflows to the Channel and dispersion. The higher the freshwater inflows up to a point, the greater the dispersion.

Dispersion in the Channel is a result of the following types of phenomena:

1) Saline density current. The saline density current proceeds along the bottom generally in an upstream direction (when averaged over a tidal cycle) from the mouth of the Channel at Morgan's Point. Past studies have shown that the majority of mixing in the Channel is due to the density current.

2) Wind induced mixing.

3) Tidal action.

4) Miscellaneous disturbances such as ship traffic, etc.

The unsteady flow water quality model of the Channel explicity takes tidal action and varying inflows into account. The dispersion term in this particular case is used to represent mixing due to the density current and various other mixing phenomena such as ship traffic and wind induced mixing. At present, changes in dispersion with changes in flow are not explicitly accounted for in the model. These issues should be subjected to further analysis and refinement in future unsteady flow modeling of the Channel.

D) Benthal Demand

The unsteady flow model runs did not explicitly account for benthal demand. At present, benthal demand is not incorporated in the Stormwater Management Model-Receiving Water Block or its successor, WRECEV, which was used in this modeling project.

For a given set of steady-state conditions, the dissolved oxygen deficit due to benthal demand is constant at a given location. When flow is varied with other factors held constant, the deficit due to benthal demand is inversely proportional to flow. As an example, in the case of a rectangular channel if the flow is doubled, the deficit due to benthal demand is reduced to one-half its original value.

During unsteady flow conditions, the behavior of benthal demand becomes more complicated due to the following types of phenomena:

1) Resuspension of benthal material during high flows. The benthal material may be resuspended and exert an elevated oxygen demand on the water column for the short time until the flow receeds.

2) The contribution of settled stormwater BOD_5 to benthal demand.

3) Decrease in benthal demand due to flushing out of the system during high flow periods.

These issues should be given further analysis in future unsteady flow modeling of the Channel.

E) Clear Creek - Sampling Priorities

The unsteady flow modeling of Clear Creek indicates that potential stormwater problems exist for future conditions (1983, 1990, 1995) for the watershed. These potenital problems are a direct result of the simulated pollutographs used as inputs to the Clear Creek unsteady flow models. Attachment 18 contains a summary of the simulated pollutographs used as inputs for the Clear Creek model. As an example, under 1975 conditions for the 1-hour duration - 2-year storm, the simulated pollutograph had a total runoff of 2,166 MG, an average BOD_5 of 8.7 mg/l, a maximum BOD_5 of 33.5 mg/l, and a minimum BOD_5 of 4.1 mg/l. For 1995 conditions at the same location, the simulated pollutograph had a total runoff of 2,291 MG, an average BOD_5 concentration of 24.2 mg/l, a maximum BOD_5 of 114 mg/l, and a minimum BOD_5 of 14.5 mg/l. Since the potential problems for Clear Creek are indicated for future watershed conditions, it is not possible to sample at the present time to verify the existence of the problems. It will probably be more beneficial to concentrate sampling effort on measuring stormwater quality/quantities for the bayou system tributary to the Houston Ship Channel.

F) Fecal Coliform Simulations

The procedure for applying the water quality standard to Texas waterways for fecal coliforms is specified in the Texas Water Quality Standards, February 1976. Briefly, for the determination of a violation of the fecal coliform

standard, the geometric mean fecal coliform content from a representative sampling of not less than 5 samples collected over not more than 30 days is computed and compared to the fecal coliform standard. The standard is the geometric mean of the samples as specified shall not exceed 200 per 100 ml, nor shall more than 10% of the samples during the 30-day period exceed 400 per 100 ml.

As an example, in applying the standard to Junction 14 (the critical junction) of the 2 year-1975 storm on Spring Creek, thirty consecutive days of simulated fecal coliform data were examined. The following table shows the simulated data (fecal coliform based on 10% of total coliform):

Day	Fecal Coliform (MPN/100 ml)	Day	Fecal Coliform (MPN/100 ml)
1	22	16	25
2	22	17	22
3	22	18	22
4	22	19	22
5	22	20	22
6	1760	21	22
7	678	22	22
8	288	23	22
9	155	24	22
10	94	25	22
11	60	26	22
12	50	27	22
13	40	28	22
14	35	29	22
15	30	30	22

Analysis indicates the standard has not been violated. The logarithmic average for this data is 39 MPN/100 ml. Only 7% of the samples exceed 400/100 ml. Similar analysis can be applied to the remaining junctions and storms.

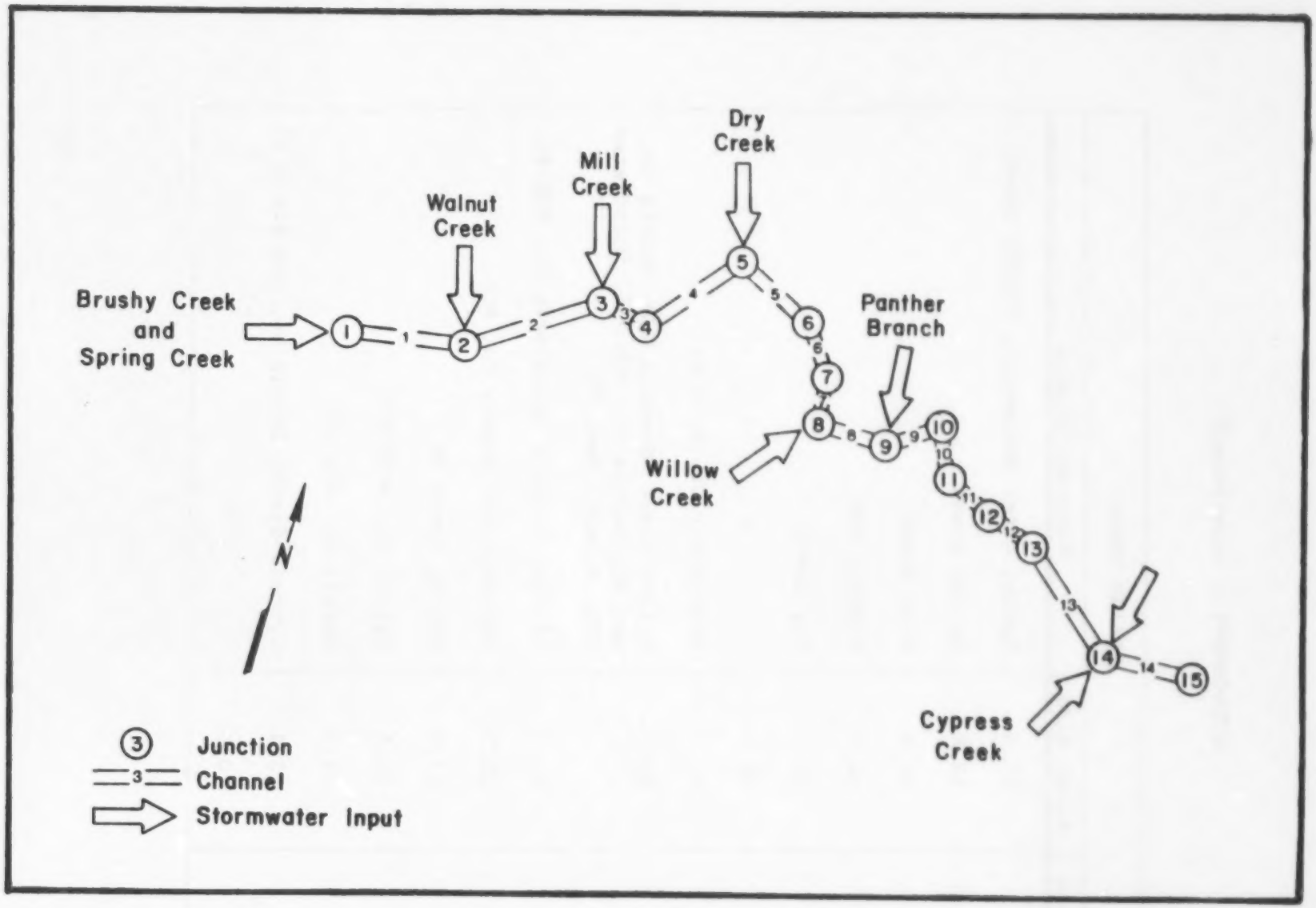
If coliforms is shown to be a potential problem in stormwater, sampling to verify its existence should proceed along the lines of measuring the fecal coliform content of major stormwater input loads as they enter the waterway and measuring fecal coliform content in the watercourse during and several days after the storm event. The most sensitive water quality modeling parameter for fecal coliforms is the coliform decay rate. Literature values were

used in the stormwater modeling. Measurement of coliforms in-stream for several days after a storm would provide data for the determination of the coliform decay rate for the stream in question.

VII. SUMMARY

The staff of the TDWR has reviewed the available nonsteady-state models currently in existence. Using historic data and data gathered in the Houston 208 study, the WRECEV model has been set up for Spring Creek, Cypress Creek, Clear Creek, the San Jacinto River (Tidal), and the Houston Ship Channel. These stormwater models can be used to evaluate the in-stream impacts of stormwater for the above referenced stream segments in the Houston Designated 208 Planning Area.

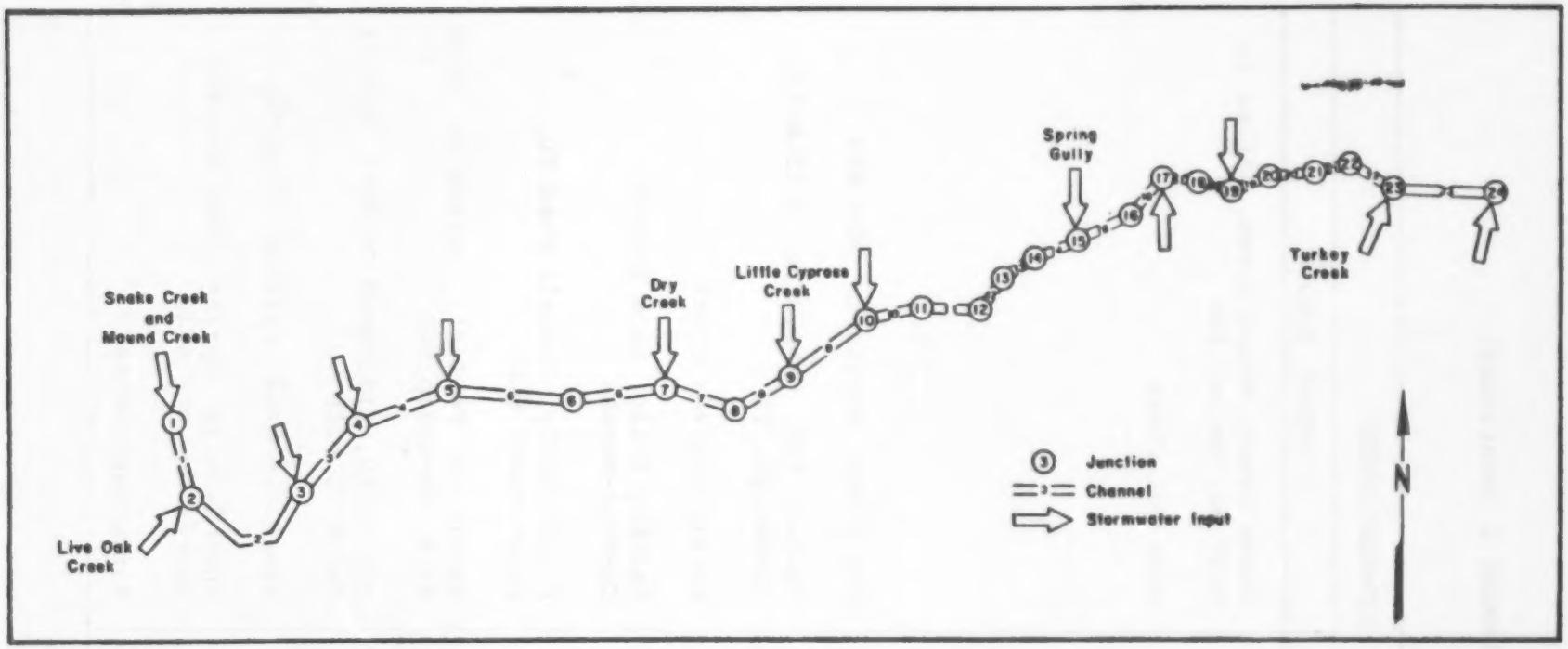
A T T A C H M E N T S



ATTACHMENT I: JUNCTION-CHANNEL REPRESENTATION OF SPRING CREEK

ATTACHMENT 1 (continued)

SPRING CREEK		
Junction	River Mile	Constant Inputs
1	47.8	Spring Creek Headwater, Brushy Creek
2	42.8	Walnut Creek
3	35.9	Mill Creek
4	34.8	Tomball STP
5	29.5	Dry Creek
6	24.5	
7	21.7	Montgomery Co. WCID #1
8	20.7	Willow Creek, Dowdell MUD, Harris Co. MUD #1, Harris Co. MUD #35, Norchester MUD, Encanto Real UD
9	17.7	Panther Branch, Montgomery Co. MUD #6
10	15.7	Southern Montgomery Co. MUD
11	13.8	Spring Creek UD
12	11.5	Harris Co. WCID #92
13	9.3	Harris Co. MUD #82
14	3.4	Cypress Creek, Harris Co. MUD #26 & 27
15	0.0	



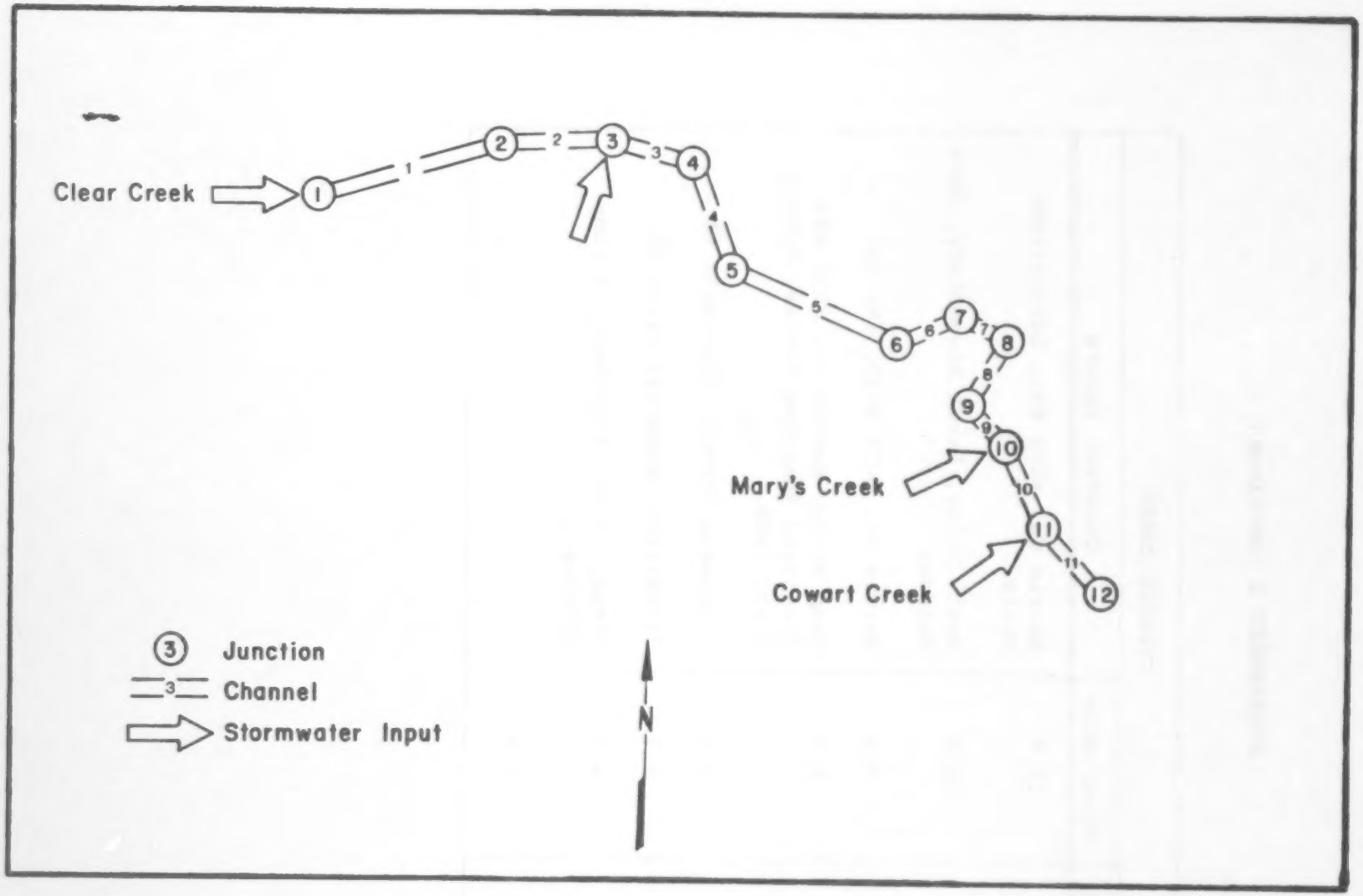
ATTACHMENT 2: JUNCTION - CHANNEL REPRESENTATION OF CYPRESS CREEK

ATTACHMENT 2 (continued)

CYPRESS CREEK		
Junction	River Mile	Constant Inputs
1	52.4	Snake Creek, Mound Creek, Waller Co. WCID #2, Waller STP
2	50.1	Live Oak Creek
3	45.7	
4	43.0	
5	40.0	
6	36.4	
7	33.0	Dry Creek, Harris Co. MUD #29
8	31.0	Cy-Fair ISD, Harris Co. WCID #113, Timberlake ID
9	28.2	Little Cypress Creek
10	24.4	Faulkey Gully, Lake Forest, Cy-Fair-Matzke
11	22.4	Pillot Gully, Tomball Road UD, Charterwood MUD
12	19.2	Harris Co. FWSD #52, Harris Co. WCID #116, Cy-Champ PUD
13	18.2	Dry Gully, Kleinwood Central, Harris Co. WCID #119
14	17.2	Bammel Central, Cypress-Klein UD
15	16.0	Spring Gully, Spring Creek Forest, Harris Co. MUD #24
16	12.8	Ponderosa Central

ATTACHMENT 2 (continued)

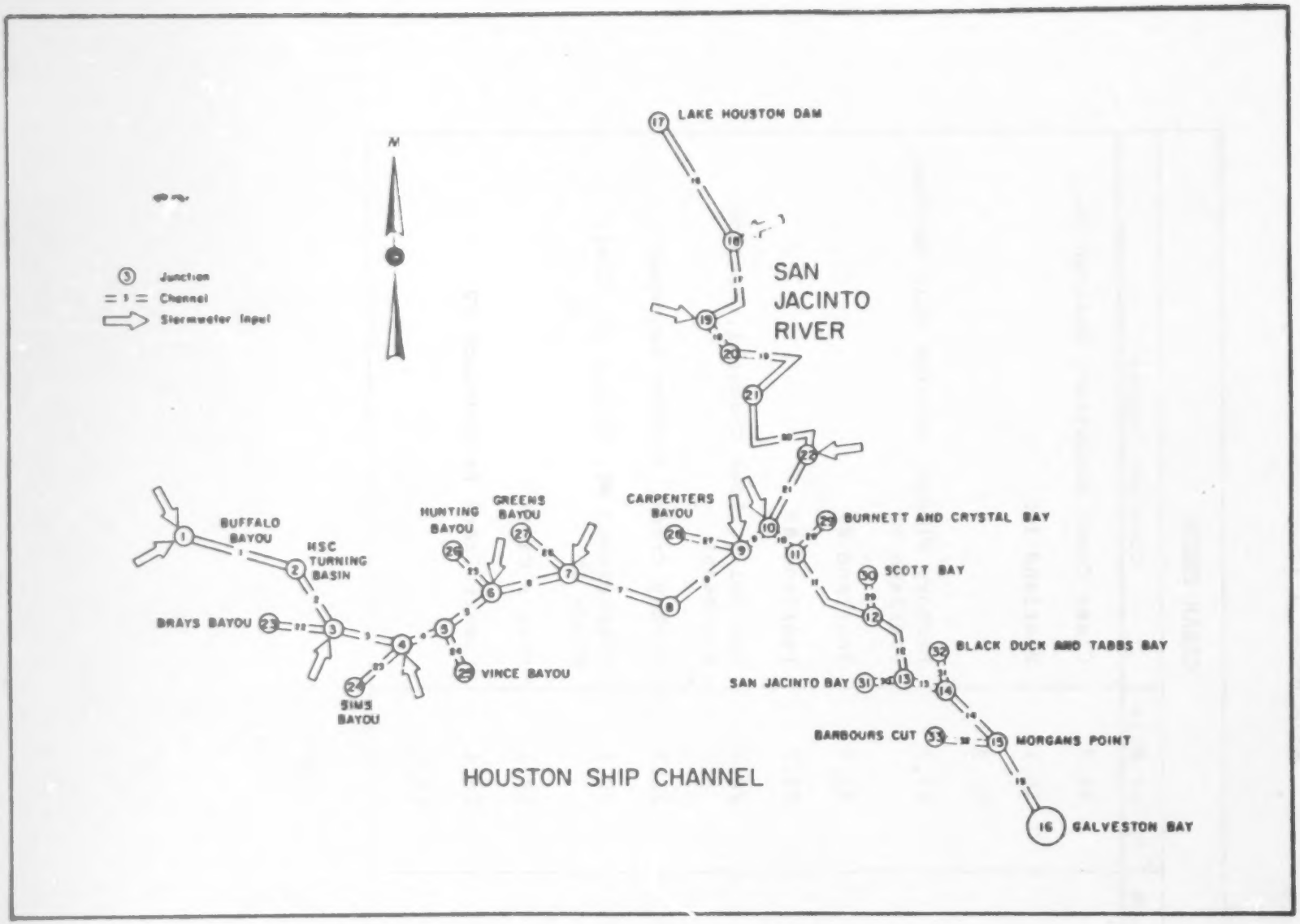
CYPRESS CREEK		
Junction	River Mile	Constant Inputs
17	11.8	Harris Co. WCID #91, Candlelight Hills
18	10.8	Seals Gully, Haude Elementary, Dove Meadows
19	9.8	Harris Co. WCID #110, CNP UD
20	8.8	Lemm Gully, Harris Co. WCID #99, Northland Shopping Center, Spring North Park
21	7.5	Inverness Forest, Stonegate #5
22	6.3	Timberlane, Memorial Hills UD
23	4.3	Turkey Creek, Treschwig, Plains Machinery
24	0.0	



ATTACHMENT 3: JUNCTION - CHANNEL REPRESENTATION OF CLEAR CREEK

ATTACHMENT 3 (continued)

CLEAR CREEK		
Junction	River Mile	Constant Inputs
1	39.0	Clear Creek Headwater, Heatran Inc.
2	36.1	Pearland ISD
3	34.2	
4	33.2	Hickory Slough, Houston Gulf Meadows, Pearland #4
5	31.0	Pearland #2
6	25.7	Pearland #3
7	22.7	Mud Gully, Lowe Chemical, Houston Southeast
8	21.7	Turkey Creek, Houston Sagemont
9	20.1	Friendswood #1, Harris Co. Clear Woods ID
10	19.1	Mary's Creek
11	16.4	Cowart Creek Friendswood #2
12	15.0	



ATTACHMENT 4 JUNCTION - CHANNEL REPRESENTATION OF THE HOUSTON SHIP CHANNEL AND THE SAN JACINTO RIVER TIDAL

ATTACHMENT 4 (continued)

HOUSTON SHIP CHANNEL		
Junction	River Mile Above Morg. Pt	Inflows/Reference
1	29.7	Buffalo & Whiteoak Bayous
2	24.7	Turning Basin
3	22.8	Brays Bayou
4	20.7	Sims Bayou
5	19.5	Vince Bayou
6	17.8	Hunting Bayou
7	15.5	Greens Bayou
8	13.3	
9	11.8	Carpenters Bayou
10	9.8	Confluence SJR
11	8.6	Burnett & Crystal Bay
12	5.2	Scott Bay
13	3.4	San Jacinto Bay
14	2.3	Black Duck & Tabbs Bays
15	0.0	Morgans Point
16	-2.0	Galveston Bay

ATTACHMENT 4 (continued)

SAN JACINTO RIVER TIDAL		
Junction	River Mile Above Confl. with HSC	Inflows/Reference
17	19.8	Lake Houston Overflow
18	15.6	
19	12.1	
20	11.1	
21	6.8	
22	2.5	
10	0.0	Confluence with HSC

ATTACHMENT 5

WRECEV INPUT DATA

Spring Creek

CHANNEL GEOMETRY

CHANNEL NUMBER	LENGTH (FT)	MANNING COEF.	AREA COEF.	AREA EXP.	WIDTH COEF.	WIDTH EXP.	FLOW (CFS)	JUNCTIONS AT ENDS	
1	26400.	.050	1.75	.830	9.50	.360	24.	1	2
2	36432.	.050	1.75	.830	9.50	.360	47.	2	3
3	5808.	.050	1.75	.830	9.50	.360	68.	3	4
4	27984.	.050	1.75	.830	9.50	.360	69.	4	5
5	26400.	.050	1.75	.830	9.50	.360	77.	5	6
6	14784.	.050	1.75	.830	9.50	.360	77.	6	7
7	5280.	.050	1.75	.830	9.50	.360	78.	7	8
8	15840.	.050	1.75	.830	9.50	.360	101.	8	9
9	10560.	.050	1.75	.830	9.50	.360	115.	9	10
10	10032.	.050	1.75	.830	9.50	.360	118.	10	11
11	12144.	.050	1.75	.830	9.50	.360	118.	11	12
12	11616.	.050	1.75	.830	9.50	.360	119.	12	13
13	31152.	.050	1.75	.830	9.50	.360	119.	13	14
14	17952.	.050	1.75	.830	9.50	.360	268.	14	15

ATTACHMENT 5 (continued)

WRECEV INPUT DATA

Spring Creek

JUNCTION GEOMETRY

JUNCTION NUMBER	BOTTOM ELEV (FT)	CONSTANT INPUTS NAME	INFLOW (CFS)	CONSTITUENT BOD5 MG/L	DO MG/L	COLIFORM MPN/100ML
1	152.71	LP10-SPRING CREEK HEADWATER & BR	24.2	1.00+00	8.00+00	1.00+02
2	140.50	LP20-WALNUT CREEK	22.5	1.00+00	8.00+00	1.00+02
3	123.65	LP30-MILL CREEK	21.5	1.00+00	8.00+00	1.00+02
4	120.97	TOMBALL STP	1.2	3.44+01	4.00+00	2.00+02
5	108.03	LP40-DRY CREEK	7.9	1.00+00	8.00+00	1.00+02
6	95.82					
7	88.98	MONTGOMERY CO WCID #1	.5	3.44+01	4.00+00	2.00+02
8	86.54	LP50-WILLOW CREEK-DOWDELL-ENCANT	23.5	1.02+01	6.90+00	1.28+02
9	79.22	LP60-PANTHER BRANCH-MONT CO MUD	13.9	5.80+00	7.30+00	1.17+02
10	74.33	SOUTHERN MONTGOMERY CO MUD	3.1	3.44+01	4.00+00	2.00+02
11	69.69	SPRING CREEK UD (FOXRUN)	.1	3.44+01	4.00+00	2.00+02
12	64.06	HARRIS CO WCID #92	.8	3.44+01	4.00+00	2.00+02
13	58.71	HARRIS CO MUD #62	.1	3.44+01	4.00+00	2.00+02
14	44.30	LP70-CYPRESS CREEK-MUD #26&27	8.2	1.60+00	7.90+00	1.02+02
15	36.00					

ATTACHMENT 6

WRECEV INPUT DATA

CYPRESS CREEK

CHANNEL GEOMETRY

CHANNEL NUMBER	LENGTH (FT)	MANNING COEF.	AREA COEF.	AREA EXP.	WIDTH COEF.	WIDTH EXP.	FLOW (CFS)	JUNCTIONS AT ENDS	
1	12144.	.050	1.50	.840	8.20	.320	22.	1	2
2	23232.	.050	1.50	.840	8.20	.320	31.	2	3
3	14256.	.050	1.50	.840	8.20	.320	36.	3	4
4	15840.	.050	1.50	.840	8.20	.320	46.	4	5
5	19008.	.050	1.50	.840	8.20	.320	55.	5	6
6	17952.	.050	1.50	.840	8.20	.320	55.	6	7
7	10560.	.050	1.50	.840	8.20	.320	67.	7	8
8	14784.	.050	1.50	.840	8.20	.320	68.	8	9
9	20064.	.050	1.50	.840	8.20	.320	91.	9	10
10	10560.	.050	1.50	.840	8.20	.320	100.	10	11
11	16896.	.050	1.50	.840	8.20	.320	101.	11	12
12	5280.	.050	1.50	.840	8.20	.320	103.	12	13
13	5280.	.050	1.50	.840	8.20	.320	105.	13	14
14	6336.	.050	1.50	.840	8.20	.320	107.	14	15
15	16896.	.050	1.50	.840	8.20	.320	119.	15	16
16	5280.	.050	1.50	.840	8.20	.320	122.	16	17
17	5280.	.050	1.50	.840	8.20	.320	128.	17	18
18	5280.	.050	1.50	.840	8.20	.320	128.	18	19
19	5280.	.050	1.50	.840	8.20	.320	134.	19	20
20	6864.	.050	1.50	.840	8.20	.320	135.	20	21
21	6336.	.050	1.50	.840	8.20	.320	136.	21	22
22	10560.	.050	1.50	.840	8.20	.320	137.	22	23
23	22704.	.050	1.50	.840	8.20	.320	149.	23	24

ATTACHMENT 6 (continued)

WRECEV INPUT DATA

CYPRESS CREEK

JUNCTION GEOMETRY

JUNCTION NUMBER	BOTTOM ELEV (FT)	CONSTANT INPUTS NAME	INFLOW (CFS)	CONSTITUENT BOD5 MG/L	DO MG/L	COLIFORM MPN/100
1	175.35	LP10-MOUND & SNAKE CR-WALLER STP	22.1	1.90+00	7.90+00	1.02+02
2	169.41	LP15-LIVE OAK CREEK	9.0	1.00+00	8.00+00	1.00+02
3	158.04	LP20-SHARP ROAD	5.0	1.00+00	8.00+00	1.00+02
4	151.07	LP25-ROCK HOLLOW	9.7	1.00+00	8.00+00	1.00+02
5	143.32	LP30	8.9	1.00+00	8.00+00	1.00+02
6	134.02					
7	125.24	LP35-DRY CREEK-MUD #29	12.8	1.60+00	7.90+00	1.02+02
8	120.07	CY-FAIR ISD WCID #113 TIMBERLA	.8	2.52+01	4.00+00	2.00+02
9	112.84	LP40-LITTLE CYPRESS CREEK	23.0	1.00+00	8.00+00	1.00+02
10	103.03	LP45-FAULKNY GULLY-LAKE FOREST S	9.0	4.30+00	7.50+00	1.14+02
11	97.86	TOMBALL RD UD - CHARTERWOOD	.6	2.52+01	4.00+00	2.00+02
12	89.60	FWSD #52 - WCID #116 - CY-CHAMP	1.6	2.52+01	4.00+00	2.00+02
13	87.01	KLEINWOOD CENTRAL - WCID #119	2.6	2.52+01	4.00+00	2.00+02
14	84.43	BAMMEL CENTRAL - CYPRESS-KLEIN U	1.7	2.52+01	4.00+00	2.00+02
15	81.33	LP50-SPRING GULLY-SPR CR FOR-MUD	12.4	1.40+00	7.00+00	1.02+02
16	73.06	PONDEROSA CENTRAL	2.6	2.52+01	4.00+00	2.00+02
17	70.48	LP55-HC FLOOD DITCH-WCID #91-CND	5.6	3.50+00	7.60+00	1.10+02
18	67.90	SEALS GULLY-HAUDE-DOVE MEADOWS	.3	2.52+01	4.00+00	2.00+02
19	65.31	LP60-IH45-WCID #110-CNP UD	5.9	3.50+00	7.60+00	1.10+02
20	62.71	WCID #99-NORTHLAND-SPR NO PRK	1.5	2.52+01	4.00+00	2.00+02
21	59.37	INVERNESS FOREST-STONEGATE #5	.7	2.52+01	4.00+00	2.00+02
22	56.27	TIMBERLANE UD-MEMORIAL HILLS	.8	2.52+01	4.00+00	2.00+02
23	51.11	LP65-TRESCHWIG CENTRAL-PLAINS MA	12.4	3.60+00	7.60+00	1.11+02
24	40.00	LP70-CONFLUENCE WITH SPRING CREE	2.3	1.00+00	8.00+00	1.00+02

ATTACHMENT 7

WRECEV INPUT DATA

Clear Creek

CHANNEL GEOMETRY

CHANNEL NUMBER	LENGTH (FT)	MANNING COEF.	AREA COEF.	AREA EXP.	WIDTH COEF.	WIDTH EXP.	FLOW (CFS)	JUNCTIONS AT ENDS	
1	15312.	.050	1.53	.879	6.03	.392	5.	1	2
2	10032.	.050	1.53	.879	6.03	.392	5.	2	3
3	5280.	.050	1.53	.879	6.03	.392	13.	3	4
4	11616.	.050	1.53	.879	6.03	.392	15.	4	5
5	27984.	.050	1.53	.879	6.03	.392	16.	5	6
6	15840.	.050	1.53	.879	6.03	.392	17.	6	7
7	5280.	.050	1.53	.879	6.03	.392	22.	7	8
8	8448.	.050	1.53	.879	6.03	.392	25.	8	9
9	5280.	.050	1.53	.879	6.03	.392	26.	9	10
10	14256.	.050	1.53	.879	6.03	.392	123.	10	11
11	7392.	.050	1.53	.879	6.03	.392	160.	11	12

ATTACHMENT 7 (continued)

WRECEV INPUT DATA

Clear Creek

JUNCTION GEOMETRY

JUNCTION NUMBER	BOTTOM ELEV (FT)	CONSTANT INPUTS NAME	INFLOW (CFS)	CONSTITUENT BOD5 MG/L	DO MG/L	COLIFORM MPN/100
1	42.00	LP1C-CLEAR CR AT FM 518 -HEATRAN	5.4	1.00+00	8.00+00	1.00+02
2	35.72	PEARLAND ISD	.0	2.02+01	4.00+00	2.00+02
3	31.60	LP2C-STATE HIGHWAY 35	7.3	1.00+00	8.00+00	1.00+02
4	29.43	GULF MEADOWS-HIKRY SLEW-PEARLND4	1.9	2.02+01	4.00+00	2.00+02
5	24.67	PEARLAND #2	1.5	2.02+01	4.00+00	2.00+02
6	13.18	PEARLAND #3	.8	2.02+01	4.00+00	2.00+02
7	6.68	MUD GULLY-LOWE-HOUSTON SOUTHEAST	30.0	4.30+00	7.30+00	1.17+02
8	4.52	TURKEY CREEK-HOUSTON SAGEMONT	35.3	2.70+00	7.60+00	1.09+02
9	1.05	FRIENDSWOOD #1 - CLEAR WOODS	.9	2.02+01	4.00+00	2.00+02
10	-1.12	LP4C-MARY'S CREEK	39.8	1.00+00	8.00+00	1.00+02
11	-6.97	LP5C-COWART CREEK-FRIENDSWOOD #2	37.3	1.60+00	7.90+00	1.03+02
12	-10.00					

ATTACHMENT 8

WRECEV INPUT DATA

Houston Ship Channel & San Jacinto River Tidal

CHANNEL GEOMETRY

CHANNEL NUMBER	LENGTH (FT)	MANNING COEF.	AREA COEF.	AREA EXP.	WIDTH COEF.	WIDTH EXP.	FLOW (CFS)	JUNCTIONS AT ENDS	
1	26400.	.030	2661.00	.100	167.00	.000	502.	1	2
2	10032.	.030	9296.00	.100	583.00	.000	665.	2	3
3	11088.	.030	8900.00	.100	583.00	.000	886.	3	4
4	6336.	.030	8900.00	.100	583.00	.000	1081.	4	5
5	8976.	.030	8900.00	.100	875.00	.000	1171.	5	6
6	12144.	.030	8900.00	.100	583.00	.000	1199.	6	7
7	11616.	.030	8900.00	.100	875.00	.000	1372.	7	8
8	7920.	.030	12200.00	.100	1023.00	.000	1391.	8	9
9	10560.	.030	12200.00	.100	1023.00	.000	1449.	9	10
10	6336.	.030	12200.00	.100	1156.00	.000	1455.	10	11
11	17952.	.030	12200.00	.100	1330.00	.000	1458.	11	12
12	9504.	.030	12200.00	.100	1662.00	.000	1458.	12	13
13	5808.	.030	12200.00	.100	1662.00	.000	1509.	13	14
14	12144.	.030	12200.00	.100	1662.00	.000	1529.	14	15
15	10560.	.030	12200.00	.100	6650.00	.000	1529.	15	16
16	22176.	.030	135.00	.500	340.00	.000	100.	17	18
17	13480.	.030	330.00	.400	335.00	.000	100.	18	19
18	5280.	.030	701.00	.300	335.00	.000	100.	19	20
19	22704.	.030	1385.00	.200	320.00	.000	100.	20	21
20	22704.	.030	4087.00	.150	450.00	.000	100.	21	22
21	13200.	.030	4788.00	.100	550.00	.000	100.	10	22
22	10560.	.050	1086.00	.100	181.00	.000	170.	3	23
23	10560.	.050	3726.00	.100	340.00	.000	84.	4	24
24	10560.	.050	1234.00	.100	333.00	.000	16.	5	25
25	10560.	.050	3987.00	.100	517.00	.000	22.	6	26
26	10560.	.050	4786.00	.100	234.00	.000	78.	7	27
27	10560.	.050	1962.00	.100	215.00	.000	100.	9	28
28	5280.	.050	1820.00	.100	910.00	.000	100.	11	29
29	5280.	.050	8970.00	.100	2990.00	.000	100.	12	30
30	5280.	.050	7120.00	.100	1780.00	.000	100.	13	31
31	5280.	.050	1390.00	.100	695.00	.000	100.	14	32
32	5280.	.050	3925.00	.100	186.00	.000	100.	15	33

ATTACHMENT 8 (continued)

JUNCTION GEOMETRY

JUNCTION NUMBER	CONSTANT INPUTS NAME	INFLOW (CFS)	CONSTITUENT BOD5 MG/L	DO MG/L	FEC. COL. PER 100
1	BUF. BAYOU + WHITE OAK BAYOU	502.0	1.00+00	8.00+00	1.00+02
2	TURNING BASIN	163.0	2.85+01	4.00+00	2.00+02
3		51.0	3.59+01	4.00+00	2.00+02
4		111.0	3.35+01	4.00+00	2.00+02
5		72.0	4.22+01	4.00+00	2.00+02
6		6.0	4.58+01	4.00+00	2.00+02
7		95.0	1.67+01	4.00+00	2.00+02
8		19.0	8.59+01	4.00+00	2.00+02
9		58.0	5.13+01	4.00+00	2.00+02
10		6.0	3.39+01	4.00+00	2.00+02
11		3.0	3.56+01	4.00+00	2.00+02
13		51.0	3.14+01	4.00+00	2.00+02
14		20.0	2.84+01	4.00+00	2.00+02
18		2.0	4.47+01	4.00+00	2.00+02
19		1.0	4.47+01	4.00+00	2.00+02
20		5.0	5.00+01	4.00+00	2.00+02
22		1.0	4.47+01	4.00+00	2.00+02
23	BRAYS BAYOU	170.0	1.00+00	8.00+00	1.00+02
24	SIMS BAYOU	84.0	1.00+00	8.00+00	1.00+02
25	VINCE BAYOU	18.0	1.00+00	8.00+00	1.00+02
26	HUNTING BAYOU	22.0	1.00+00	8.00+00	1.00+02
27	GREENS AND HALLS BAYOU	78.0	1.00+00	8.00+00	1.00+02

ATTACHMENT 9

STORMWATER MODELING RESULTS

Spring Creek

DISSOLVED OXYGEN			
Storm	Minimum Dissolved Oxygen Concentration (mg/l)	Location of Minimum Dissolved Oxygen Concentration	
		Time After Storm Began (Hrs)	Junction - River Mile
1 Mo - 1975	6.32 6.32	26, 28, 30, 32 42, 44, 46, 48	4 - RM 34.8 7 - RM 21.7
6 Mo - 1975	6.32	54, 56, 58, 60	7 - RM 21.7
2 Yr - 1975	6.21	8	4 - RM 34.8
2 Yr - 1983	6.27	8	4 - RM 34.8
2 Yr - 1990	6.27	6, 8	4 - RM 34.8
2 Yr - 1995	6.26	6, 8	4 - RM 34.8

ATTACHMENT 9 (continued)

STORMWATER MODELING RESULTS

Spring Creek

TOTAL COLIFORM			
Storm	Maximum Coliform Concentration (MPN/100 ml)	Location of Maximum Coliform Concentration	
		Time After Storm Began (Hrs)	Junction - River Mile
1 Mo - 1975	15,500	6	1 - RM 47.8
6 Mo - 1975	77,400	12	14 - RM 3.4
2 Yr - 1975	64,300	10	14 - RM 3.4
2 Yr - 1983	71,100	10	14 - RM 3.4
2 Yr - 1990	75,300	10	14 - RM 3.4
2 Yr - 1995	177,000	10	14 - RM 3.4

ATTACHMENT 10

STORMWATER MODELING RESULTS

Cypress Creek

DISSOLVED OXYGEN			
Storm	Minimum Dissolved Oxygen Concentration (mg/l)	Location of Minimum Dissolved Oxygen Concentration	
		Time After Storm Began (Hrs)	Junction - River Mile
1 Mo - 1975	6.53 6.53	8, 10, 12 16, 18	2 - RM 50.1 3 - RM 45.7
6 Mo - 1975	6.33	10	6 - RM 36.4
2 Yr - 1975	6.15	8	6 - RM 36.4
2 Yr - 1983	6.15	8	6 - RM 36.4
2 Yr - 1990	6.06	6	21 - RM 7.5
2 Yr - 1995	5.99	6	22 - RM 6.3

ATTACHMENT 10 (continued)

STORMWATER MODELING RESULTS

Cypress Creek

TOTAL COLIFORM			
Storm	Maximum Coliform Concentration (MPN/100 ml)	Location of Maximum Coliform Concentration	
		Time After Storm Began (Hrs)	Junction - River Mile
1 Mo - 1975	35,500	8	19 - RM 9.8
6 Mo - 1975	574,000	4	17 - RM 11.8
2 Yr - 1975	624,000	4	18 - RM 10.8
2 Yr - 1983	659,000	4	18 - RM 10.8
2 Yr - 1990	708,000	2	17 - RM 11.8
2 Yr - 1995	728,000	2	17 - RM 11.8

ATTACHMENT 11

STORMWATER MODELING RESULTS

Clear Creek

DISSOLVED OXYGEN			
Storm	Minimum Dissolved Oxygen Concentration (mg/l)	Location of Minimum Dissolved Oxygen Concentration	
		Time After Storm Began (Hrs)	Junction - River Mile
1 Mo - 1975	5.60	24	6 - RM 25.7
6 Mo - 1975	5.59	12	6 - RM 25.7
2 Yr - 1975	5.05	10	9 - RM 20.1
2 Yr - 1983	3.32	16	9 - RM 20.1
2 Yr - 1990	1.82	14	9 - RM 20.1
2 Yr - 1995	0.22	14	9 - RM 20.1

ATTACHMENT 11 (continued)

STORMWATER MODELING RESULTS

Clear Creek

TOTAL COLIFORM			
Storm	Maximum Coliform Concentration (MPN/100 ml)	Location of Maximum Coliform Concentration	
		Time After Storm Began (Hrs)	Junction - River Mile
1 Mo - 1975	761,000	4	3 - RM 35.9
6 Mo - 1975	915,000	4	3 - RM 35.9
2 Yr - 1975	935,000	4	3 - RM 35.9
2 Yr - 1983	931,000	4	3 - RM 35.9
2 Yr - 1990	936,000	4	3 - RM 35.9
2 Yr - 1995	937,000	4	3 - RM 35.9

ATTACHMENT 12

STORMWATER MODELING RESULTS

Houston Ship Channel

DISSOLVED OXYGEN			
Storm	Minimum Dissolved Oxygen Concentration (mg/l)	Location of Minimum Dissolved Oxygen Concentration	
		Time After Storm Began (Days)	Junction - River Mile
1 Mo - 1975	.70	4	6 - RM 17.8
6 Mo - 1975	.00	4	6 - RM 17.8
2 Yr - 1975	.02	4	9 - RM 11.8
2 Yr - 1983	.00	3, 4	9 - RM 11.8 11 - RM 8.6
2 Yr - 1990	.00	3, 4, 5	6 - RM 17.8 8 - RM 13.3 9 - RM 11.8 11 - RM 8.6
2 Yr - 1995	.00	3, 4, 5, 6	6 - RM 17.8 8 - RM 13.3 9 - RM 11.8 11 - RM 8.6

ATTACHMENT 12 (continued)

STORMWATER MODELING RESULTS

Houston Ship Channel

FECAL COLIFORM			
Storm	Maximum Coliform Concentration (MPN/100 ml)	Location of Maximum Coliform Concentration	
		Time After Storm Began (Hrs)	Junction - River Mile
1 Mo - 1975	31	34	2 - RM 24.7
6 Mo - 1975	26	12	2 - RM 24.7
2 Yr - 1975	34	14	10 - RM 9.8
2 Yr - 1983	352	14	10 - RM 9.8
2 Yr - 1990	345	14	10 - RM 9.8
2 Yr - 1995	333	14	10 - RM 9.8

ATTACHMENT 13

STORMWATER MODELING RESULTS

San Jacinto River Tidal

DISSOLVED OXYGEN			
Storm	Minimum Dissolved Oxygen Concentration (mg/l)	Location of Minimum Dissolved Oxygen Concentration	
		Time After Storm Began (Days)	Junction - River Mile
1 Mo - 1975	5.70	7	22 - RM 2.5
6 Mo - 1975	4.70	6	22 - RM 2.5
2 Yr - 1975	4.26	5	22 - RM 2.5
2 Yr - 1983	4.06	4	22 - RM 2.5
2 Yr - 1990	3.94	4	22 - RM 2.5
2 Yr - 1995	3.91	4	22 - RM 2.5

ATTACHMENT 13 (continued)

STORMWATER MODELING RESULTS

San Jacinto River Tidal

FECAL COLIFORM			
Storm	Maximum Coliform Concentration (MPN/100 ml)	Location of Maximum Coliform Concentration	
		Time After Storm Began (Hrs)	Junction - River Mile
1 Mo - 1975	39	19	22 - RM 2.5
6 Mo - 1975	118	18	19 - RM 12.1
2 Yr - 1975	192	13	19 - RM 12.1
2 Yr - 1983	2,900	16	22 - RM 2.5
2 Yr - 1990	2,890	16	22 - RM 2.5
2 Yr - 1995	2,880	15	22 - RM 2.5

ATTACHMENT 14

SENSITIVITY ANALYSIS

Dissolved Oxygen

Parameter	Spring Creek[1]	Clear Creek[2]	Cypress Creek[3]	Houston Ship[4] Channel	San Jacinto[5] River Tidal
2 Yr 1975 Run	6.21	5.05	6.15	.02	4.26
BOD Decay (+20%)	6.07	4.68	5.98	.00	4.18
BOD Decay (-20%)	6.35	5.42	7.01	1.15	4.74
Reaeration Rate (+20%)	6.29	5.06	6.25	.52	4.80
Reaeration Rate (-20%)	6.12	5.03	6.04	.00	3.77
Storm DO (+20%)	6.98	5.69	6.71	.50	4.41
Storm DO (-20%)	5.43	4.40	5.59	.00	4.22
Storm BOD (+100%)	5.51	3.37	5.30	.00	3.54
Storm BOD (-50%)	6.56	5.88	6.57	3.16	5.85

[1] Spring Creek: Junction 4 (River Mile 34.8) Hour 8

[2] Clear Creek: Junction 9 (River Mile 20.1) Hour 10

[3] Cypress Creek: Junction 6 (River Mile 36.4) Hour 8

[4] Houston Ship Channel: Junction 9 (River Mile 11.8) Time Cycle 12

[5] San Jacinto River Tidal: Junction 22 (River Mile 2.5) Time Cycle 13

ATTACHMENT 15

SENSITIVITY ANALYSIS

Coliform

Parameter	Spring Creek[1]	Clear Creek[2]	Cypress Creek[3]	Houston Ship[4] Channel	San Jacinto[5] River Tidal
2 Yr 1975 Run	64,300	935,000	624,000	34	192
Coliform Decay (+20%)	63,100	927,000	615,000	31	182
Coliform Decay (-20%)	65,500	944,000	634,000	38	203
Storm Coliform (+100%)	129,000	1,870,000	1,248,000	67	384
Storm Coliform (-50%)	32,200	468,000	312,000	18	96

[1] Spring Creek: Junction 14 (River Mile 3.4) Hour 10

[2] Clear Creek: Junction 3 (River Mile 34.2) Hour 4

[3] Cypress Creek: Junction 18 (River Mile 10.8) Hour 4

[4] Houston Ship Channel: Junction 10 (River Mile 9.8) Hour 14

[5] San Jacinto River Tidal: Junction 19 (River Mile 12.1) Hour 13

ATTACHMENT 16

NONPOINT SOURCE POLLUTOGRAPHS

Buffalo, Whiteoak & Brays Bayous
One-Hour Duration Storms

	Buffalo Bayou	Whiteoak Bayou	Brays Bayou
1975 Condition			
One-Month Storm:			
Total Volume	756 MG	534 MG	2,262 MG
Total BOD_5	162,050 lbs	152,380 lbs	469,360 lbs
Average BOD_5	25.7 mg/l	34.2 mg/l	24.9 mg/l
Maximum BOD_5	117.0 mg/l	82.0 mg/l	72.0 mg/l
Minimum BOD_5	6.8 mg/l	10.1 mg/l	0.1 mg/l
Six-Month Storm:			
Total Volume	1,492 MG	1,109 MG	4,053 MG
Total BOD_5	322,966 lbs	280,346 lbs	813,310 lbs
Average BOD_5	25.9 mg/l	30.3 mg/l	24.1 mg/l
Maximum BOD_5	167.0 mg/l	110.0 mg/l	80.0 mg/l
Minimum BOD_5	3.2 mg/l	5.6 mg/l	0.05 mg/l
Two-Year Storm:			
Total Volume	2,178 MG	1,723 MG	6,290 MG
Total BOD_5	510,462 lbs	432,415 lbs	1,186,758 lbs
Average BOD_5	28.1 mg/l	30.1 mg/l	22.6 mg/l
Maximum BOD_5	211.0 mg/l	135.0 mg/l	84.0 mg/l
Minimum BOD_5	1.3 mg/l	2.2 mg/l	0.02 mg/l

ATTACHMENT 17

USGS QUANTITY/QUALITY FOR 1970-1976

Buffalo, Whiteoak & Brays Bayous

	Buffalo Bayou @ Houston USGS 08074000 (73 Samples)	Whiteoak Bayou @ Houston USGS 08074500 (84 Samples)	Brays Bayou @ Houston USGS 08075000 (64 Samples)
Biochemical Oxygen Demand			
Average (all samples)	7.60 mg/l (n = 73)	10.12 mg/l (n = 84)	7.42 mg/l (n = 64)
Average (Q > Qav.)	6.25 mg/l (n = 34)	13.50 mg/l (n = 26)	8.10 mg/l (n = 28)
Average (Q < Qav.)	8.78 mg/l (n = 39)	9.46 mg/l (n = 57)	6.89 mg/l (n = 36)
Flow weighted average (all samples)	5.04 mg/l (n = 73)	7.64 mg/l (n = 84)	6.22 mg/l (n = 64)
Flow weighted average (Q > Qav.)	4.71 mg/l (n = 34)	7.52 mg/l (n = 26)	6.23 mg/l (n = 28)
Flow weighted average (Q < Qav.)	7.99 mg/l (n = 39)	10.40 mg/l (n = 58)	6.33 mg/l (n = 36)
Maximum (all samples)	26 mg/l	60 mg/l	36 mg/l
Maximum (Q > Qav.)	17 mg/l	60 mg/l	36 mg/l
Minimum (all samples)	1.2 mg/l	0.5 mg/l	0.3 mg/l
Minimum (Q > Qav.)	1.2 mg/l	1.2 mg/l	0.8 mg/l
Qav.	274 cfs	75 cfs	106 cfs

ATTACHMENT 18

CLEAR CREEK - NODE 50

Simulated Pollutograph Statistics

1975 Conditions	
Total Runoff	2,166 MG
Total BOD_5	156,753 lbs
Flow Weighted Average BOD_5 Concentration	8.7 mg/l
Maximum BOD_5 Concentration	33.5 mg/l
Minimum BOD_5 Concentration	4.1 mg/l
1995 Conditions	
Total Runoff	2,291 MG
Total BOD_5	462,631 lbs
Flow Weighted Average BOD_5 Concentration	24.2 mg/l
Maximum BOD_5 Concentration	113.8 mg/l
Minimum BOD_5 Concentration	14.5 mg/l